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EN COMMISSION CHEZ
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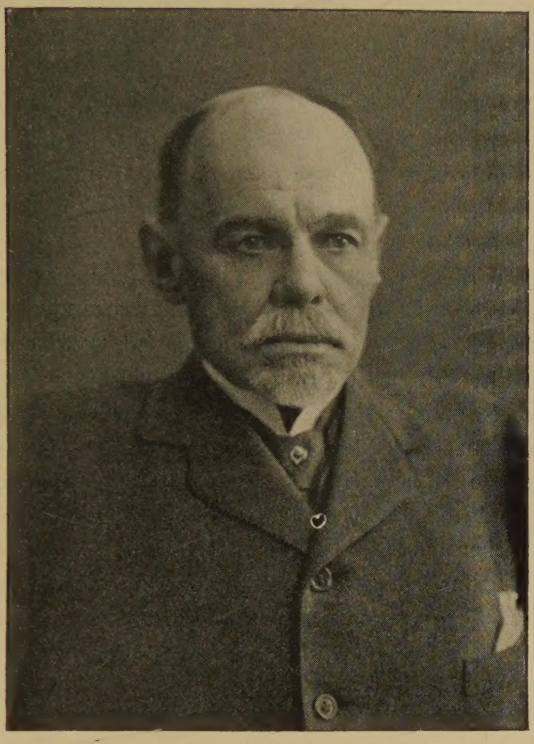
IMPRIMERIE BIANCO LUNO A/S

Gustaf Ekman.
1852–1930.



Am 26. Februar dieses Jahres starb in Gothenburg Gustaf Ekman, Sohn des Fregattenkapitäns J. E. Ekman und seiner Gattin geborenen Freiherrin Kurck, die einem uralten finnischen Adelsgeschlecht angehörte, bekannt in der Geschichte Finnlands und Schwedens im 15.—16. Jahrhundert, unter der Zeit des Wasa-Hauses. Das Gechlecht Ekman hat seit einem Jahrhundert eine hervorragende Rolle in der industriellen und socialen Entwicklung der Stadt Gothenburg gespielt. Zu den grossen Donationen, die sein Onkel, Konsul Ekman, der Hochschule zu Gothenburg gab, fügte Gustaf Ekman eine weitere, indem er ein Laboratorium für hydrographische Untersuchungen stiftete. Sein

Interesse für die Meeresforschung erwachte schon in seinen Jugendjahren, als er mit einem Kollegen an dem chemischen Laboratorium zu Uppsala, Dr. CRONANDER, aus eigenen Mitteln eine grosse Segeljacht mit den damals bekannten besten Instrumenten für hydrographische Tieflotungen einrichtete und im Sommer 1876 die ersten systematischen Untersuchungen über die Ostsee, das Kattegat und das Skagerak durch Quersektionen ausführte, wobei er die damals übliche Methode, den Salzgehalt mit Areometern zu bestimmen, aufgab und zu der gegenwärtig üblichen Titrierungsmethode von Wasserproben, die mit EKMANS isolierenden Wasserholern heraufgeholt waren, überging. Zufolge der Genauigkeit, womit die Observationen nach exakten Methoden ausgeführt wurden, gaben diese hydrographischen Sektionen schon vor mehr als 50 Jahren ein vollständiges Bild der Wassercirkulation in diesem Teile des Meeres, der in den Annalen der Internationalen Meeresforschung »The Transitional Area« benannt wird. GUSTAF EKMAN gehörte zu der Klasse von Naturforschern, die man Pioniere der Wissenschaft genannt hat. Er hatte das Glück, auf noch ungebautem Boden zu arbeiten und wusste Schwierigkeiten mit Scharfsinn und unermüdlichem Interesse zu überwinden. Schon ein Jahr nachher hatte er Gelegenheit, dies zu beweisen, als er in der über die ganze Ostsee von seinem Verwandten Professor F. L. EKMAN geleiteten grossen Expedition teilnahm. Seine Erfolge veranlassten im folgenden Jahr Landeshauptman EHRENWÄRD zu Gothenburg ihn zu bitten, die hydrographischen Verhältnisse während der Winterheringsfischerei in dem Skagerak zu untersuchen. Dabei machte er die Entdeckung, welche ein Hauptproblem für die internationale Meeresforschung ist, dass nämlich die Fischwanderungen in unseren nordischen Gegenden auf Veränderungen in den hydrographischen Verhältnissen beruhen. Wasserschichten von verschiedenem Ursprung und verschiedenem Salzgehalt, Temperatur und Planktoninhalt wechselten und es zeigte sich, dass diese Veränderungen in Zusammenhang stehen mit den grossen Heringsfischereiperioden, welche einmal jedes Jahrhundert seit tausend Jahren im Skagerak eingetreten sind. Es war der Anfang einer solchen Periode, den EKMAN im Jahre 1878 konstatiert hatte. Das Ende der Periode hatte er Gelegenheit, mit JOHAN HJORT und mir in 1896 zu studieren. Als EKMAN und ich diese Resultate

dem König Oskar II vorlegten, beschloss er, die Einladung zum Kongress in Stockholm in 1899, der zu der Bildung der internationalen Meeresforschung führte, auszuschicken.

Die Wirksamkeit Ekmans innerhalb derselben, wurde von dem President M. Maurice, mit folgenden Worten in seiner Begrüssungsrede bei der Eröffnung der Zusammenkunft in Kopenhagen im Mai dieses Jahres geschildert:

»Avant de passer à l'ordre du jour, je vous prie de vous joindre à moi pour saluer la mémoire de quelques anciens collègues récemment décédés.

Le Conseil vieillit, et c'est une des douleurs de la vieillesse d'assister à la mort de ses amis. Ainsi déplorons-nous la perte de Gustaf Ekman, homme d'affaires, savant, inventeur, bon ami, qui a été associé à nos travaux, ou comme expert, ou comme délégué de son pays à peu près dès la création du Conseil.

Grand travailleur, malgré l'exigence des affaires auxquelles il était associé dans sa ville de Göteborg, il trouvait le moyen de consacrer une grande partie de sa vie à des études hydrologiques, qui étaient pour lui un véritable délassement et auxquelles — nous en avons tous été témoins — il apporta une contribution remarquable.

Nous avons tous profité des résultats de ses études scientifiques, de l'exactitude des appareils qu'il a inventés et de ses bons conseils, mais ce n'est pas seulement le savant que nous regrettons c'est surtout l'homme — l'homme qui joignait à un caractère droit et courageux un esprit sympathique et capable d'amitié.

De tous ses amis je crois que celui qui lui était le plus étroitement lié était notre très cher collègue, Otto Pettersson, auquel, en votre nom, j'adresse l'expression de la sympathie profonde du Conseil, en le priant d'être notre interprète auprès des fils et des filles de notre ami décédé«.

Schon ein Jahr vor der Zusammenkunft war Ekman von der unheilbaren Krankheit, die sein Leben zu Ende führte, angegriffen. Diese Krankheit war aber schmerzlos und griff seine Seelenkraft und sein wissenschaftliches Interesse, welches bis zu seinem Tode dasselbe blieb, nicht an. Mein Freund erlitt einen sanften Tod.

Otto Pettersson.

Die Hydrographie des Barentsmeeres.

Von

Bruno Schulz, Hamburg.
Deutsche Seewarte.

1. Lage und Bodengestalt.

Der breite nordwesteuropäische Schelf verschmälert sich an der norwegischen Küste erheblich, am meisten nördlich der Lofoten, wo er nur eine Breite von etwa 25 sm besitzt. Nördlich davon gewinnt er wieder erheblich grössere Ausdehnung und bildet dort einen Teil des Europa und Asien im Norden vorgelagerten Schelfes, der Abdachung der eurasiatischen Landmasse nach dem tiefen Nordpolarbecken hin. Der westlichste und zugleich breiteste Teil dieses polaren eurasiatischen Schelfes wird vom Barentsmeere bedeckt. Es liegt ungefähr in dem Viereck, das durch den 70. und 80. Parallelkreis wie von 16° und 60° ö. Lg. umschlossen wird. Im einzelnen liegt seine westliche Grenze in 15° bis 17° ö. Lg. und wird durch den Steilabfall des Schelfes nach dem Europäischen Nordmeere gebildet. Dieser beginnt wie ziemlich allgemein in den nordpolaren Gebieten erst in 400 bis 500 m Tiefe, also nicht schon bei der 200 m-Linie, der konventionellen Grenze des Schelfes. Die Südgrenze ist durch die Festlandküste zwischen Finmarken und den Ausläufern des Ural gegeben, wenn wir das Weisse Meer einschliessen. Die Ostgrenze wird durch die Inseln Waigatsch und Nowaja Semlja gebildet, die Nordost- und Nordgrenze durch die Inselgruppen Franz Josephs Land und Spitzbergen sowie die zwischen diesen Inseln zu ziehenden Verbindungslinien. Innerhalb dieses Rahmens umfasst das Barentsmeer rund $1^1/_2$ Millionen qkm, ist also mehr als doppelt so gross wie die Nordsee mit Einschluss des Skagerrak und mehr als drei mal so gross wie die Ostsee.

Die Gestalt des Meeresbodens (Abb. 1) steht in bezug auf die Stärke der Gliederung etwa zwischen der langsam nach Südosten anstei-

genden Nordsee und der in einzelne Becken aufgelösten Ostsee. — Nach den Rändern des Barentsmeeres hin dehnen sich in Anlehnung an die

——— von deutscher, — — — von russischer Seite im Sommer 1927 ausgeführte hydrographische Schnitte, die Punkte auf den deutschen Schnitten bedeuten die einzelnen Stationen

1 Bäreninsel-Senke.
2 Spitzbergen-Bank.
3 Nordkap-Rücken.
4 Skolpen-Bank
5 Mittel-Bank
6 Nord-Bank
} auf der Mittel-Schwelle

I, II, III die Mittelschwelle querende Senken.

Dunkle Schraffur: Land.
Helle — : 200 bis 300 m Tiefe.
Mittlere Schraffur: 0 bis 200 m Tiefe.
Ohne — : Tiefer als 300 m.

Abb. 1. Übersicht über die Tiefenverhältnisse des Barentsmeeres nach Nansen 1904 und 1927, L. Breitfuss und A. Smirnow 1905 sowie nach der Deutschen Admiralitätskarte XIII, 31.

umgebenden Länder und Inseln flache Meeresgebiete mit weniger als 200 m Tiefe aus, nur an zwei Stellen sind tiefere Ausgänge nach den angrenzenden Meeren vorhanden, nämlich zwischen Franz Josephs Land

und Nowaja Semlja nach dem Nordpolarmeer sowie zwischen Bäreninsel und Finmarken in der sog. Bäreninselsenke nach dem Europäischen Nordmeere. Im Norden bildet die ausgeprägte Schwelle zwischen Spitzbergen und Franz Josephs Land mit weniger als 200 m Tiefe die eigentliche Nordgrenze des Barentsmeeres. Dieser die beiden genannten Inselgruppen tragende Sockel ist auf der Westseite Spitzbergens sehr schmal, verbreitert sich aber erheblich nach Süden und Südosten. Besonders flach ist die südliche unterseeische Fortsetzung der spitzbergischen Inselgruppe, die von der 100 m-Isobathe umschlossene Spitzbergenbank, auf welcher sich die Hoffnungsinsel sowie die Bäreninsel bis zu 365 bezw. 536 m Höhe erheben. Östlich von König Karls-Land dehnt sich der flacher als 200 m befindliche Meeresboden in der »Nordbank« bis rund 40° ö. Lg. aus. Weiter nach Osten verschmälert sich diese Erhebung stark, sie ist aller Wahrscheinlichkeit nach in etwa 60° ö. Lg. mit dem Franz Josephs Land tragenden Sockel verbunden. Nach Norden senkt sich der Meeresboden zwischen Spitzbergen und Franz Josephs Land nach den Tiefen des Nordpolarbeckens hin, ohne dass eine weitere absperrende Barre vorhanden ist. Nowaja Semlja ist an seiner Westseite in wechselnder Breite von einem flacheren Gebiet als 200 m Tiefe begleitet, das im Süden überleitet zu dem der russischen Küste vorgelagerten flachen Teile des Barentsmeeres, in dem das Gebiet mit weniger als 200 m Tiefe seine grösste Ausdehnung im Barentsmeere überhaupt hat, sogar die 100 m-Linie ist vielfach mehr als 100 bis 200 km von der Küste entfernt. An dem westlichen Teil der Murmanküste und an der Küste von Finmarken verläuft die 200 m-Linie meist dicht der Küste. Im Weissen Meere senkt sich im Kandalakscha-Busen der Boden kesselförmig bis zu 350 m Tiefe.

Der mehr als 200 m tiefe Teil des Barentsmeeres ist nun keineswegs gleichmässig nach der Bäreninselsenke hin geneigt, sondern in charakteristischer Weise und hydrographisch bedeutungsvoll gegliedert, insbesondere durch einen fast meridional verlaufenden unterseeischen Rücken, der sich annähernd parallel von Nowaja Semlja zwischen etwa 33° und 40° ö. Lg. hinzieht und fast in seiner ganzen Ausdehnung geringere Tiefen als 300 m besitzt. Im Süden gehört diesem Rücken die »Skolpenbank« an, im Norden eine auf rund 75° n. Br. zwischen 33° und 42° ö. Lg. gelegene Bank, die »Mittelbank«, und die bereits erwähnte »Nordbank«; in allen erhebt sich der Meeresboden auf weniger als 200 m Tiefe. Die Entstehung dieser annähernd meridionalen »Mittelschwelle« ist nach Nansen wahrscheinlich tektonisch bedingt, ebenso wie des Nowaja Semlja—Rückens sowie der Erhebung mit der Spitzbergenbank und dem spitzbergischen Archipel. Die Gestalt des Meeresbodens

im einzelnen hat zu der Vorstellung geführt, dass die genannten Schwellen bei einer früheren höheren Lage des Meeresbodens durch fliessendes Wasser und während der Eiszeit durch Gletschereis umgestaltet worden sind. In der Tat kann man auf einer Tiefenkarte unschwer ein flussnetzähnliches, nach der Bäreninselsenke zusammenlaufendes System von Rinnen erkennen, über das vielleicht am leichtesten eine Übersicht gewonnen wird, wenn wir flussaufwärts fortschreiten[1]). Die Bäreninselsenke verläuft annähernd westöstlich und ist bis rund 30° ö. Lg. über 400 m tief; südöstlich der Bäreninsel sind die grössten Tiefen des Barentsmeeres überhaupt festgestellt worden mit 535 m und 548 m auf 20° bezw. 21° ö. Lg. Die 400 m-Tiefenlinie weist im Osten drei Ausbuchtungen auf, durch welche annähernd die Richtungen von Verzweigungen der Bäreninselsenke nach Osten hin angedeutet sind. Der nördlichste Zweig wendet sich parallel der Ostabdachung der Spitzbergenbank nach Nordosten, Norden und weiter nach Nordwesten und endet schliesslich in Richtung auf die Hinlopenstrasse. Diese Rinne, welche die Hoffnungsinsel in weitem Bogen umschliesst, sei NANSEN folgend, als »Hoffnungsinsel-Senke« bezeichnet. Auf etwa 76° n. Br. zweigt von dieser eine zwischen Nord- und Mittelbank quer über die Mittelschwelle führende Senke mit Tiefen zwischen 200 und 300 m ab, die nördlich 74° n. Br. die tiefste Verbindung zwischen den Meeresgebieten westlich und östlich der Mittelschwelle darstellt und als deren weitere Fortsetzung man wohl die über 300 m tiefe Senke zwischen Franz Josephs Land und Nowaja Semlja ansehen darf. Die zweite Abzweigung von der Bäreninselsenke führt in gerader Fortsetzung über die Mittelschwelle hinweg und weist auf dieser in einer schmalen Rinne Tiefen über 300 m auf. Hier haben wir die tiefste Verbindung zwischen den Gebieten östlich und westlich der Mittelschwelle. Die dritte Abzweigung der Bäreninselsenke ist zunächst nach Südosten gerichtet, sie verzweigt sich dann in eine die Mittelschwelle unmittelbar nördlich der Skolpenbank querende und eine südlich dieser Bank nach Südosten führende Rinne. Die östlich der Mittelschwelle gelegene Senke, die »Ostsenke«, hat annähernd meridionale Erstreckung, die Tiefen nehmen in ihr von Süden nach Norden zu bis auf 421 m. Im Norden ist sie durch eine fast bis 200 m emporsteigende Schwelle gegen die tiefe Rinne abgegrenzt, die Franz Joseph Land und Nowaja Semlja von einander trennt. Rein morphologisch lassen sich demnach die folgenden auch hydrographisch differenzierten Teile des Barentsmeeres unterscheiden: a) die Bäreninselsenke und die Westmulde, b) die Mittelschwelle, c) die Spitzbergen- und Nordbank, d) die

[1]) Vergl. die Karte in: F. NANSEN, Spitzbergen. Leipzig 1921. S. 40.

Ostmulde, e) der flache Südosten und das Weisse Meer, f) die Rinne zwischen Franz Josephs Land und Nowaja Semlja.

2. Der hydrographische Zustand der Oberflächenschicht des Barentsmeeres.

Durch die Lage des Barentsmeeres in der Übergangszone zwischen dem durch die atlantische Trift erwärmten Europäischen Nordmeere und dem mit Eis bedeckten Nordpolarbecken sowie dem sibirischen Schelfmeere ist die Ausbildung sehr gegensätzlicher hydrographischer Verhältnisse sowohl an der Oberfläche wie auch in der Tiefe bedingt. Von Westen dringt zwischen Spitzbergen und Nordnorwegen das ganze Jahr hindurch ozeanisches Wasser in das Barentsmeer ein, im Osten macht sich kontinentaler Einfluss geltend und die polare Abkühlung sowie Eisbedeckung reichen erheblich weiter südwärts als im östlichen Teil des Europäischen Nordmeeres. Die Zustände im Barentsmeere leiten damit über zu den Zuständen des sibirischen Schelfmeeres, in dem das Eis meist bis dicht an die Küste reicht.

Die bislang gesammelten Beobachtungen reichen selbst an der Oberfläche nicht aus, um für alle Jahreszeiten die Verteilung der wichtigsten hydrographischen Faktoren, nämlich von Temperatur und Salzgehalt, darzustellen. Nur für drei Monate (Juli, August, September) besitzen wir Karten der mittleren Oberflächentemperatur, zu deren Zeichnung W. Wiese (36) das gesamte verfügbare Material benutzte; für August liegen ausserdem die aus dem dichten Beobachtungsnetz des R. F. D. »Poseidon« 1927 abgeleiteten Karten der Oberfläche vor (29, vgl. Abb. 2, 3). Danach zeigt sich in der Wärmeverteilung im August als grosser gemeinsamer Zug für das ganze Gebiet eine Abkühlung mit zunehmender Breite von 11° bis 6° in Küstennähe bis zu Werten unter 0° an der Südgrenze des Treibeises, in dessen Nähe die Temperaturabnahme besonders beträchtlich ist. Am reinsten ist die Abkühlung von Süden nach Norden in dem westlichen Gebiete bis rund 30° ö. Lg. ausgeprägt, dort verlaufen die Isothermen fast breitenparallel, östlich davon, wo die Küste nach südöstlicher Richtung umbiegt, sind sie südlich $74^1/_2$° n. Br. nach Südosten gerichtet, nördlich davon ist eine scharfe Ausbuchtung nach Nordosten vorhanden, ebenso weisen die Isothermen westlich von Nowaja Semlja eine Ausbuchtung nach Norden auf. Östlich 30° ö. Lg. sind also Abzweigungen von der bis dahin westöstlich setzenden Oberflächenströmung festzustellen und zwar eine nach Südosten und zwei nach nördlicher Richtung setzende Stromarme. Diese werden bestätigt durch den Verlauf der Isohalinen, jedenfalls soweit überhaupt Darstellungen

der Isohalinen vorhanden sind (29, 18, Tafel VII u. VIII). In dem westlichsten Teile des Barentsmeeres ist der Verlauf der Isohalinen beherrscht durch die Scharung der Linien parallel dem Südrande des Treibeises, durch das in einzelnen Armen erfolgende Vordringen salzreichen und warmen Wassers atlantischer Herkunft und endlich durch die Aus-

nach Oberflächenbeobachtungen des R. F. D. »Poseidon« bis 25° O-Lg. vom 2. bis 10. Sept., östlich 26° O-Lg. vom 31. Juli bis 22. Aug. 1927.

Abb. 2.

breitung salzarmen und warmen Wassers parallel der Küste. Der Salzgehalt des der Küste vorgelagerten Küstenwassers nimmt mit der Entfernung von der Küste zu. Rechnen wir dieses, das dem Bankwasser an der norwegischen Küste entspricht, bis zur 34,6 $^0/_{00}$-Isohaline, so schwankte die horizontale Ausdehnung senkrecht zur Küste im August 1927 von etwa 40 bis 120 sm. Die 34,0 $^0/_{00}$-Isohaline verlief der Küste

in einem Abstande von 8 bis 30 sm annähernd parallel. Der Verlauf dieser und auch der benachbarten Isohalinen lässt eine starke Beeinflussung durch die in den beiden Regionen westlich und östlich der Varanger-Halbinsel dem Meere zufliessenden Süsswassermengen erkennen, und zwei grosse an der Meeresoberfläche südlich $70^1/_2°$ n. Br. aus-

nach Oberflächenbeobachtungen des R. F. D. »Poseidon« bis 25° O-Lg. vom 2. bis 10. Sept., östlich 26° O-Lg. vom 31. Juli bis 22. Aug. 1927.

Abb. 3.

gebildete Wirbel dürften auf diesen Zufluss von Süsswasser und die weitere Ausbreitung des leichten Oberflächenwassers zurückzuführen sein, sie ist auch von erheblichem Einfluss auf die Verteilung des Oberflächenplanktons.

Nördlich der Region des Küstenwassers kommen wir in den Einflussbereich des eigentlichen atlantischen Wassers. Auf 26° ö. Lg.

konnte ein Salzgehalt von über 35 ‰ an drei Stellen nachgewiesen werden, in $72^2/_3°$, $73^1/_3°$ und $73^2/_3°$ n. Br., auf 30° ö. Lg. nur noch auf $73^1/_2°$ n. Br. und östlich davon überhaupt nicht mehr. Betrachten wir den Verlauf der 34,9 ‰-Isohaline, so erkennen wir, dass das salzreiche atlantische Wasser, das kurz als »Westwasser« bezeichnet sei, in zwei breiten Zungen, die durch ein in 73° n. Br. gelegenes Salzgehaltsminimum von einander getrennt sind, nach Osten vordringt. Innerhalb dieser von der 34,9 ‰-Isohaline umschlossenen Fläche sind die Salzgehaltsänderungen bemerkenswert gering. Bei dem weiteren Vordringen nach Osten tritt erhebliche Mischung ein. Der südliche Arm biegt bald nach Südosten ab und verzweigt sich. Die nördliche der beiden über 26° ö. Lg. hinaus vordringenden Zungen atlantischen Wassers ist erheblich kräftiger ausgebildet als die südliche, sie verzweigt sich ebenfalls. Besonders markant hebt sich die östlich 35° ö. Lg. nach Norden gerichtete Abzweigung hervor. Zwischen diesen zungenförmigen Fortsetzungen des atlantischen Stromes lagert salzärmeres Wasser bezw. bewegt sich in umgekehrter Richtung, sodass wir hier ein fingerförmiges Ineinandergreifen von Bewegungen salzreichen und warmen sowie salzärmeren, kalten Wassers haben, das von wirbelartigen Wasserbewegungen innerhalb der obersten 25 m-Schicht begleitet ist. Die Dichtelinien zeigen an der Grenze beider entgegengesetzt gerichteter Bewegungen charakteristische Aufwölbungen, die auf dem Schnitte auf $33^1/_2°$ ö. Lg. in $72^1/_2°$ und $73^1/_2°$ ö. Lg. in der oberen Wasserschicht gut erkennbar sind (vgl. Abb. 12). Nördlich des an der Oberfläche auftretenden Dichtemaximums befindet sich, wie ein Vergleich mit der Oberflächensalzgehaltskarte auf Abb. 3 zeigt, West-, südlich davon Ostströmung. Es sind dies die gleichen Erscheinungen, wie sie von Böhnecke an der Grenze des Ostgrönlandstromes festgestellt worden sind[1]). Der wellenförmige Verlauf von Isothermen und Isohalinen ist sehr gut auch aus den dicht liegenden Beobachtungen auf den Fahrten des »Malygin« im Juni—Juli 1928 (38, S. 31 ff.) erkennbar. — Im allgemeinen treten in diesem Gebiet, das als »Mischregion von West- und Ostwasser« bezeichnet werden kann, die grössten Salzgehaltsunterschiede in breitenparalleler Richtung auf, und da das nach Osten vordringende Westwasser im Norden weit stärker vermischt wird, verschiebt sich das Salzgehaltsmaximum auf den einzelnen Meridianen ostwärts immer weiter nach Süden; es wurde 1927 zwischen 26° und 30° ö. Lg. zwischen $72^1/_2°$ und 74° n. Br., auf $33^1/_2°$ ö. Lg. in $72^1/_2°$ und $73^1/_3°$ n. Br. und auf 38° ö. Lg. schon in 71° bis $71^3/_4°$ n. Br. angetroffen.

[1]) G. Böhnecke, E. Hentschel u. H. Wattenberg. Über die hydrographischen, chemischen und biologischen Verhältnisse an der Meeresoberfläche zwischen Island und Grönland. Annalen der Hydrographie u. s. w. 58. 1930. S. 237.

— Die dritte sich als selbständig heraushebende Region ist das vor der Eisgrenze liegende Schmelzwassergebiet. Es ist die Region der grossen Salzgehalts- und Temperaturgradienten, die Polarfront an der Oberfläche des Meeres. Im Westen, in Nähe der Bären Insel, reicht sie am weitesten nach Süden. Das leichte Schmelzwasser des nördlichen

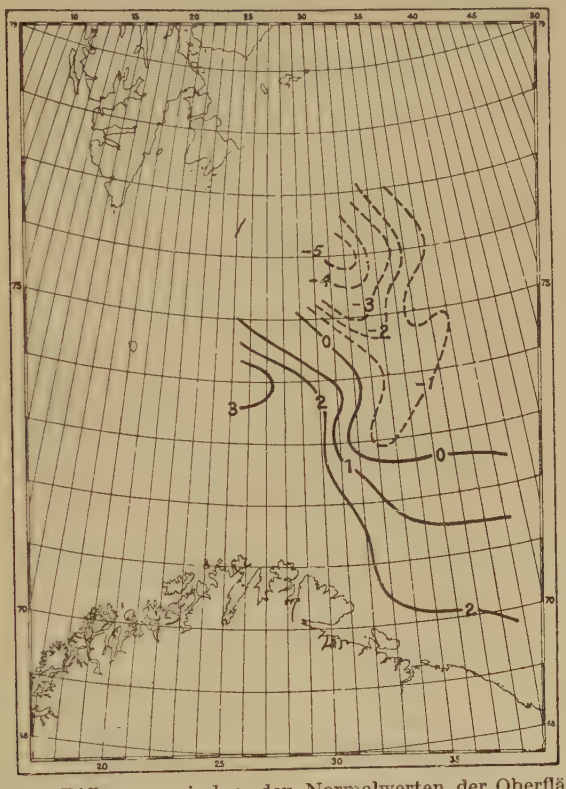


Abb. 4. Differenz zwischen den Normalwerten der Oberflächentemperatur von Wiese und den 1927 gewonnenen Beobachtungen.

\+ = August 1927 wärmer als normal.
— = — 1927 kälter - —

Barentsmeeres breitet sich unter dem Einflusse der Erdrotation vor allem an der Westseite des Barentsmeeres, östlich von Spitzbergen und der Bäreninsel, nach Süden aus. Das Vordringen des salzreichen atlantischen Wassers nach Norden ist wahrscheinlich als eine Kompensationsbewegung aufzufassen und man wird annehmen können, dass diese nach Richtung und Stärke mit dem Grade der Ausbildung des Schmelzwassers parallel gehende Schwankungen aufweist. Dass diese recht erheblich sein können, zeigt der im August 1927 festgestellte Zustand. Der Kern

des Nordstromes lag in 37° bis 38° ö. Lg., während er sich im Mittel etwa 5° weiter westlich befindet, auch 1928 war dies nach den Malygin-Beobachtungen der Fall. In diesen Gebieten können demnach, wie im Jahre 1927, die Temperaturanomalien besonders gross sein (vergl. Abb. 4).

Infolge der geschilderten eigentümlichen Temperatur- und Salzgehaltsverteilung an der Oberfläche des Barentsmeeres ist der Verlauf der Beziehungskurve von Temperatur und Salzgehalt nördlich und

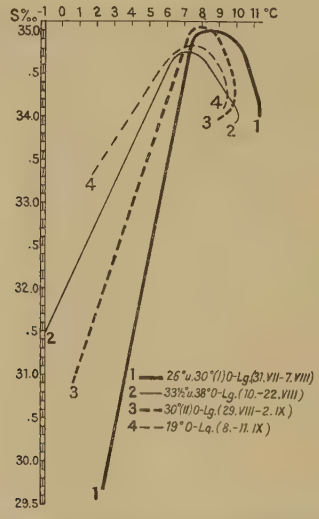


Abb. 5. Temperatur-Salzgehaltsdiagramme des Oberflächenwassers des Barentsmeeres VIII—IX. 1927.

südlich des Salzgehaltsmaximums verschieden (vergl. Abb. 5). Im Süden ist Steigerung des Salzgehalts mit Temperaturabnahme verbunden, im Norden ist es umgekehrt. Die Anfang August 1927 auf 26° und 30° ö. Lg. gewonnenen Beobachtungen ergaben im Süden eine starke Salzgehaltszunahme bei langsamer Abnahme der Temperatur. Innerhalb des Hauptausbreitungsgebietes des atlantischen Wassers ändert sich der Salzgehalt nur wenig. Da gleichzeitig die Temperatur mit Zunahme der Breite abnimmt, weist die Beziehungslinie zwischen Temperatur und Salzgehalt beim Übergang zu diesem Gebiete eine starke Krümmung auf, ebenfalls an dessen Nordgrenze beim Übergang zur Polarfront, wo die grossen Temperatur- und Salzgehaltsgradienten gleichsinnig sind. Für $33^1/_2°$ und 38° ö. Lg. ergab sich eine gleichartige Kurve, doch waren die höchsten angetroffenen Salzgehalte niedriger und bei gleichen Salzgehalten war das Wasser kälter. Bei der Wiederholung des Schnittes auf 30° ö. Lg. waren die Temperaturen infolge der fortgeschrittenen Jahreszeit sämtlich niedriger besonders in Küstennähe und im Norden.

Die Beobachtungen auf 19° ö. Lg. wurden noch später gewonnen, die abgeleitete TS-Kurve ist daher noch weiter im gleichen Sinne verschoben.

Die Beobachtungen 1927 erfolgten ungefähr zur Zeit der stärksten Erwärmung. In den anderen Jahreszeiten sind andere Beziehungen gültig, wie die Wiederholungsbeobachtungen auf 30° ö. Lg. schon andeuten. Nach Knipowitsch (18, S. 1465 f.) ist anzunehmen, dass die niedrigste Temperatur an der Oberfläche des Barentsmeeres in der ersten

Abb. 6. Mittlere Eisgrenzen.

Hälfte des April eintritt. Dann herrschen in der Nordkapströmung auf der Länge der Bären-Insel Temperaturen bis über + 4°, nach Osten nimmt die Temperatur ab, sie steigt auf dem Kolameridian kaum über + 2,5° und auf 42° und 43° ö. Lg. nur wenig über 0°. Nach Norden und Osten nimmt die Temperatur ab bis auf —1,8° bis —1,9° unter dem Eise und nach der Murmanküste auch auf 0° und darunter, sodass sich dann das Temperaturmaximum nicht an der Küste befindet, sondern innerhalb des Nordkapstromes und seiner Verzweigungen. Erst von Anfang Juni an ist das Wasser in Küstennähe stärker erwärmt als innerhalb des Nordkapstromes, dieser Zustand dauert bis Ende September.

Auf weiten Flächen des Barentsmeeres ist lange Zeit des Jahres hindurch das Wasser so weit abgekühlt, dass Eisbildung eintritt. Die Nachrichten über die Eisverhältnisse im Barentsmeere wie auch von den übrigen nordpolaren Gebieten werden von dem Dänischen

Meteorologischen Institut gesammelt (24). Neuerdings werden die Eisnachrichten aus den russischen Gebieten, also insbesondere aus dem Weissen Meere, den Zugängen zur Kara See u. s. w. auch von dem russischen Hydrographischen Amt mit eingehenden kartographischen Darstellungen und textlichen Erläuterungen veröffentlicht (25). Für den Zeitraum 1898 bis 1922, also für 25 Jahre, sind für die Monate April bis August mittlere Eisgrenzen abgeleitet worden (23), vergl. Abb. 6.

Im April ist die Bären-Insel noch von Eis umschlossen und die Grenze verläuft von dort zunächst ostwärts und weiter in weitem Bogen bis Kap Swatoi Noss an der Murman-Küste. Im Mai ist die Bären-Insel auch noch nicht frei vom Eis, die Grenze ist aber im allgemeinen ein wenig nach Norden und Nordosten zurückgewichen, nur an der Murman-Küste reicht das Eis weiter westwärts bis zu den Sem-Inseln. Der Juni bringt stärkeren Rückgang des Eises; die Grenze verläuft dann nördlich der Bären-Insel bis 30° ö. Lg. auf 75° n. Br., dann ein wenig südwärts bis 74° Br., 50° Lg. und weiter in Bogenform nach Kap Kanin; der Eingang ins Weisse Meer ist also frei. Im Juli und August zieht sich die Eisgrenze vor allem im Osten schnell weiter zurück. Die Kara- und Iugorstrasse werden passierbar. Bei der Durchführung der Handelsschiffahrt nach dem Ob und Jenissei wird damit gerechnet, dass diese Strassen ab 10. August, ev. mit Eisbrecherhülfe, befahrbar sind. Im September beginnt das Eis wieder langsam vorzurücken, die Handelsschiffe müssen die von der Kara See nach dem Barentsmeer führenden Strassen vor dem 15. Oktober passiert haben.

Im einzelnen aber bestehen erhebliche Ausnahmen von diesen mittleren Zuständen. An der Murmanküste kann sich das Eis zuweilen auch westlicher als bis zu den Sem-Inseln ausdehnen, ausnahmsweise sogar bis zur Insel Kildin. In den ruhigen Buchten der Murmanküste ist Eisbildung im Winter die Regel, auch in der Bucht von Alexandrowsk (vergl. 3, Tafel IX). Besonders weit südwärts reichte das Eis im Jahre 1929. Die Eisgrenze war im April nur 80 sm vom Nordkap entfernt, lag also fast 120 sm südlicher als gewöhnlich. Auch im Mai und Juni reichte das Eis erheblich südlicher als im Mittel und im Mai wurden zwischen Vardö und der Kola-Bucht dicht an der Murmanküste Eisberge angetroffen, was bis dahin noch nie beobachtet worden war. Im Juli lag die Eisgrenze östlich 30° Lg. bereits nördlicher als gewöhnlich, aber die Bären Insel war auch im Juli noch von Eis umgeben, erst im August hatte die Eisgrenze annähernd normale Lage, allerdings wurden Eisberge selbst bei der Bären Insel noch angetroffen. Ebenfalls sehr weit, wenn auch nicht gleich extrem weit südlich dehnte sich das Eis im April—Mai 1902, 1912, 1913 und 1917. Ungewöhnlich weit nördlich befand

sich das Eis z. B. im April 1916, wo das Eis erst auf 75° n. Br., also nördlich der Bären Insel auftrat; auf der Länge zwischen Vardö und der Kola-Bucht lag es in $76^1/_2$° n. Br., also 270 sm nördlicher als 1929. — Im Spätsommer weicht das Eis nicht selten soweit zurück, dass Franz Josephs Land zu Schiff erreichbar ist. In den Jahren von 1880 bis 1928 wurde, wenn überhaupt der Versuch gemacht wurde nach Franz Josephs Land zu kommen, dies in 18 Jahren erreicht, in den Jahren 1886, 1904, 1910, 1912, 1915, 1924 aber schlugen die Versuche fehl. Ganz ohne Eisschwierigkeiten nach Franz Josephs Land zu kommen, gelang ausser 1873, dem Entdeckungsjahre dieser Inselgruppe, bislang nur wieder 1923 und zwar dem Untersuchungsschiff »Persey« (19, S. 37). Die Verbreitung des Eises im Barentsmeere hängt in erster Linie ab von der Strenge des Winters, also von der Menge des Eises überhaupt, dann von der vorherrschenden Windrichtung und endlich auch von den Meeresströmungen. Das extrem weit nach Süden erfolgte Vordringen des Eises im Frühjahr 1929 steht z. B. in Zusammenhang mit einer lang andauernden Periode von nördlichen und nordöstlichen Winden (24, 35). Die Menge des in den einzelnen Jahren auftretenden Eises ändert sich im allgemeinen nicht sprunghaft von Jahr zu Jahr, es ist vielmehr eine recht erhebliche Erhaltungstendenz vorhanden und eisarme und eisreiche Jahre treten gruppenweise auf. Wiese ist es gelungen, allgemeine Beziehungen zwischen der Grösse der mit Eis bedeckten Fläche und der Luftdruckverteilung über Nordwesteuropa und dem Atlantischen Ozean in den vorhergehenden Monaten sowie der Eismenge des Barentsmeeres im Vorjahre aufzustellen, die recht befriedigende Eisprognosen für die einzelnen Monate von Mai bis August auf einen bis drei Monate voraus ermöglichten. Die Gesamtfläche des vom Eise bedeckten Teiles des Barentsmeeres schwankt nach den bisherigen Feststellungen im April zwischen 1 und $1^1/_3$ Millionen qkm, im Mai zwischen $^3/_4$ und $1^1/_4$ Millionen qkm, im Juni zwischen $^1/_2$ und 1, im Juli von $^1/_4$ bis $^3/_4$ und im August zwischen $^1/_6$ und $^1/_2$ Millionen qkm. Die Zahlen sind stark abgerundet, da die Südgrenze zu ungenau festgelegt ist, um genauere Angaben zu rechtfertigen (33, 34).

Eine recht bemerkenswerte Erscheinung bilden die zahlreichen innerhalb des Meereises auftretenden Eisberge, die während der Eisschmelze besonders zur Zeit des stärksten Eisrückganges, also von Juni bis August, auch in grosser Zahl weit vor dem Eisrande angetroffen werden (Abb. in 8, Taf. IV). Nach einer von W. Wiese durchgeführten statistischen Untersuchung aller aus den Jahren 1899–1928 vorliegenden Eisbergbeobachtungen lassen sich anscheinend zwei Regionen als besonders eisbergreich feststellen; diese sind das Gebiet nordwärts der Bären Insel

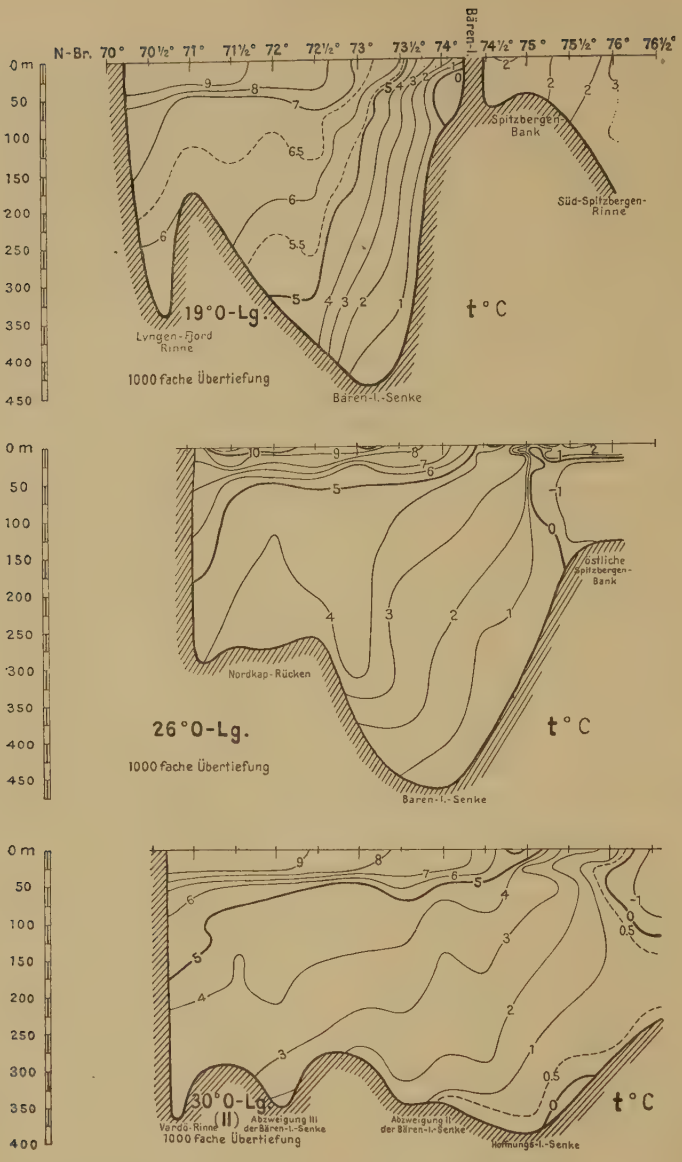


Abb. 7. Temperatur auf 19°, 26°, 30° O-Lg nach Beobachtungen des R.F.D. »Poseidon« im August—September 1927.

bis etwa 28° ö. Lg. und das Gebiet südsüdwestlich von Franz Josephs Land von 33° bis 50° ö. Lg. Hierzu stimmt, dass 1927 auf 26° und 30° ö. Lg. keine Eisberge gesichtet wurden, dagegen auf $33^1/_2$° ö. Lg. von $74^1/_2$° Br. an insgesamt 19 und auf 38° Lg. von 76° Br. an bis zur Eisgrenze 23 Eisberge, dort wurde ausserdem bei klarer Sicht vom Eis-

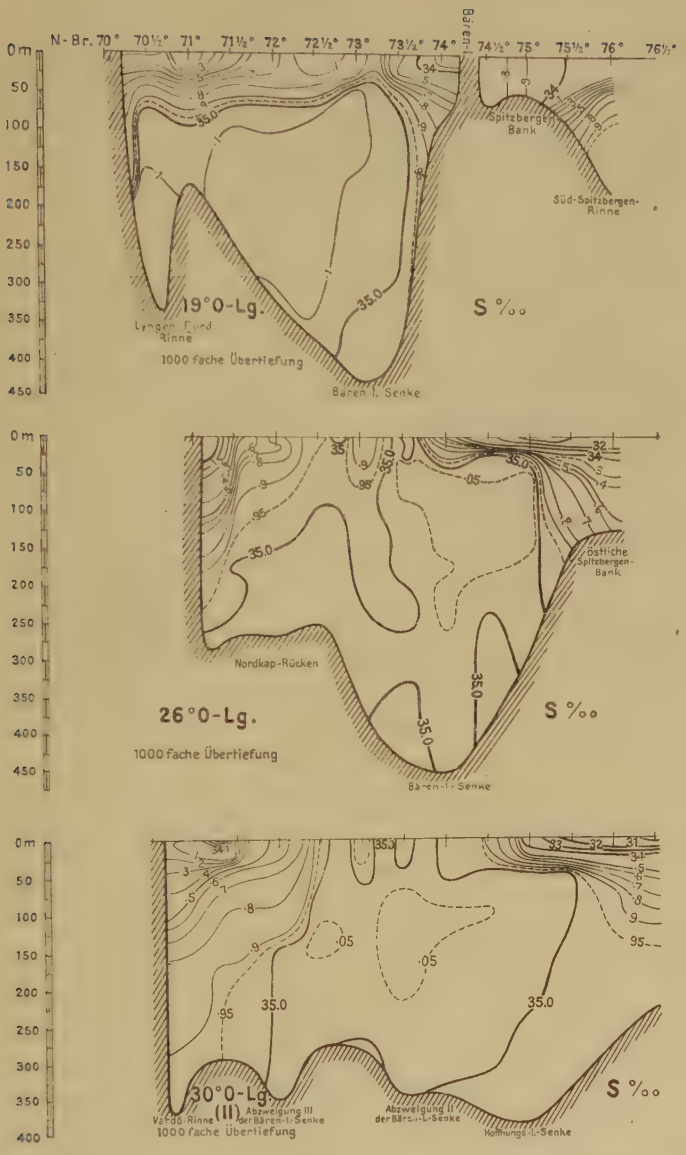


Abb. 8. Salzgehalt auf 19°, 26°, 30° O-Lg nach Beobachtungen des R.F.D. »Poseidon« im August—September 1927.

rande aus festgestellt, dass sich auch innerhalb des dichten Treibeises noch zahlreiche grosse Eisberge befanden. Die Höhe der 1927 angetroffenen Eisberge schwankte zwischen 15 und 33 m, die horizontale Ausdehnung betrug bis zu etwa 100 m. Wiese berichtet, verschiedentlich im Barentsmeere Eisberge bis zu 600 m Länge gesehen zu haben (39,

S. 63). Die Ansicht, dass die Eisberge von Westspitzbergen nach Süden und dann durch die Nordkapströmung in das innere Barentsmeer getrieben werden, dürfte nicht zutreffend sein (20). Als Ursprungsgebiet sind ohne Zweifel die Gletscher von Ostspitzbergen, Franz Josephs Land und Nowaja Semlja anzusehen.

3. Der hydrographische Zustand der tieferen Wasserschichten.

a. Das Gebiet der Bäreninselsenke und der Westmulde.

Der westlich der Mittelschwelle und südlich der Spitzbergenbank gelegene Teil des Barentsmeeres nimmt dadurch eine ausgeprägte Sonderstellung ein, dass das Wasser des Atlantischen Ozeans ungehinderten Zugang hat durch die etwa 240 sm breite und bis über 400 m Tiefe hinabreichende Bäreninselsenke zwischen der Bäreninsel und der norwegischen Küste. Die im August—September 1927 auf 19°, 26° und 30° ö. Lg. gewonnenen Schnitte (29) zeigen übersichtlich den hier herrschenden hydrographischen Zustand (vergl. Abb. 7 und 8). Alle drei Schnitte haben folgende gemeinsame Züge: küstennahes warmes und salzarmes Bank- oder Küstenwasser, warmes atlantisches Wasser mit einem Salzgehalt von 35 $^0/_{00}$ und darüber, über der Spitzbergenbank salzärmeres Wasser mit negativen Temperaturen und endlich in Bodennähe der Bäreninselsenke verhältnismässig salzreiches und kaltes Wasser mit nach Osten abnehmender Temperatur.

Dicht an der Westgrenze des Barentsmeeres (auf 19° ö. Lg.) ist der die Küste begleitende Gürtel von Küstenwasser besonders ab 75 m Tiefe nur schmal, aber der steile Anstieg der Dichtelinien lässt den Schluss zu, dass die Ostbewegung hier mit erheblicher Geschwindigkeit erfolgt. Nördlich davon dehnt sich unterhalb von 50 bis 75 m Tiefe ein Gebiet mit Wasser von über 35,1 $^0/_{00}$ sowie geringer Temperaturänderung mit der Breite. Die Abkühlung mit wachsender Tiefe ist der wesentlichste die Dichtezunahme mit der Tiefe bedingende Faktor. In breiter Front dringt hier das atlantische Wasser im sog. Nordkapstrom nach Osten vor. Oberhalb des die Lyngenfjordrinne von der Bäreninselsenke trennenden Rückens sind sowohl die Temperatur wie besonders der Salzgehalt erniedrigt, auch der Sauerstoffgehalt ist einwandfrei niedriger als südlich und nördlich davon und zwar ist die Beeinflussung bis etwa 100 m oberhalb des Rückens bemerkbar. Dies lässt darauf schliessen, dass über dem Rücken eine langsamere Wasserbewegung vorhanden ist als über den beiden benachbarten Rinnen. Bereits hier erweist sich die Bodengestaltung als die Wasserbewegung erheblich beeinflussend, dies tritt in den weiter östlich gelegenen Teilen des Barentsmeeres als noch weit bedeutungsvoller hervor.

Die höchsten Salzgehalte mit Werten von über 35,1 ‰ finden sich in der Lyngenfjord-Rinne von etwa 160 m Tiefe ab und im südlichen Teil der Bäreninselsenke. Vor allem dort dringt das atlantische Wasser nach Osten vor. Von Bodennähe an reicht das Wasser mit mehr als 35,1 ‰ bis 100 m Tiefe und noch höher, unter 73° Br. gar bis 50 m Tiefe hinauf. Innerhalb des von der 35,1 ‰-Isohaline umschlossenen Gebietes ist eine schwach, aber unverkennbar ausgebildete Zone maximalen Salzgehaltes mit von Süden nach Norden abnehmender Tiefenlage festzustellen, die sich bei Abnahme des Salzgehaltes bis an die Oberfläche zwischen 73° und 73½° n. Br. verfolgen lässt. Die Isohalinen verlaufen sowohl oberhalb wie unterhalb des Salzgehaltsmaximums den Isothermen annähernd parallel, z. B. fallen die 35,1 ‰-Isohaline und die 6,5° und 5°-Isotherme fast zusammen, ebenso die 35,0- und 34,95-Isohalinen mit den 2°- und 6,7°- bezw. 1°- und 6,8°-Isothermen. Die Beziehungen zwischen Temperatur und Salzgehalt sind also zu beiden Seiten des Salzgehaltsmaximums verschieden (vergl. Abb. 9).

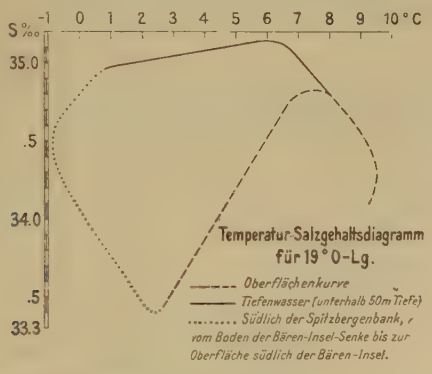


Abb. 9. Temperatur-Salzgehalts-Diagramm für 19°0-Lg im September 1927.

Am Südabhange der Spitzbergenbank nimmt der Salzgehalt von unten nach oben zunächst langsam, dann schneller ab bis zu den südlich der Bäreninsel auftretenden, bereits erwähnten niedrigen Werten; hier geht überall Temperatur- und Salzgehaltsabnahme parallel bis auf die oberste 50 m-Schicht, in der infolge zunehmender sommerlicher Erwärmung abnehmender Salzgehalt mit steigender Temperatur verbunden ist. Das in Abb. 9 dargestellte TS-Diagramm stellt in der ausgezogenen Linie die für das Wasser unterhalb 50 m Tiefe bestehenden Beziehungen dar. Das reinste atlantische Wasser, das auf diesem Schnitt nach Osten vordringt, hat einen Salzgehalt von 35,15 ‰ bei 6 bis 6½° Temperatur; es wird mit Annäherung an die norwegische Küste und Tiefen abnahme mit dem etwas wärmeren und erheblich salzärmeren Küsten-

wasser vermischt, die TS-Kurve geht schliesslich in die bereits betrachtete Oberflächenkurve über (Abb. 5). Nach dem Boden der Bäreninselsenke hin tritt Vermischung mit Wasser von 0,8° und 34,97 ‰ ein, das östlicher Herkunft ist (vergl. S. 314). Auf dem Abhang der Spitzbergen-Bank vermischt sich dieses mit Wasser von etwa 34,5 ‰ und —0,7°, das südlich der Bären-Insel in 50 m Tiefe auftritt; die Kurve geht dann in jene Beziehung über, die für das durch Einstrahlung erwärmte Schmelzwasser an der Oberfläche gültig ist (vergl. Abb. 5 und 9).

Auf 26° ö. Lg. war die Verteilung der hydrographischen Elemente

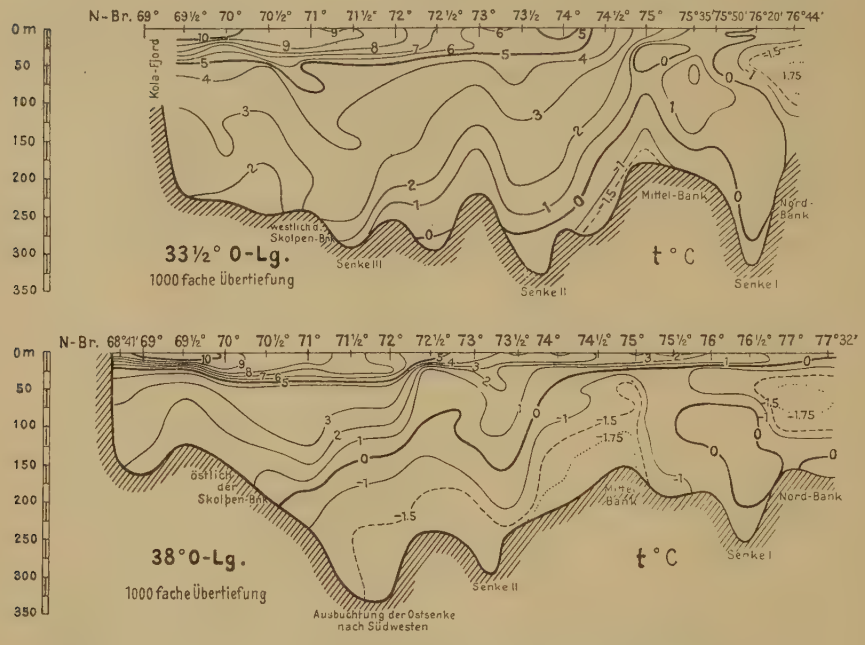


Abb. 10. Temperatur auf 33½ und 38° O-Lg nach Beobachtungen des R.F.D. »Poseidon« im August 1927.

noch ähnlich wie auf 19° ö. Lg. Das kalte Winterwasser auf der Spitzbergenbank hebt sich hier deutlicher ab als südlich der Bären-Insel mit Salzgehalten von 34,7 bis 34,3 ‰ und Temperaturen zwischen —1,1° und —1,5°. Es ist durch eine etwa 10 bis 20 m mächtige oberflächennahe Schicht von 1 bis 2° und 31½ bis 32½ ‰ überlagert.

Der östlichste durch diese hydrographische Region führende Schnitt auf 30° ö. Lg. weist ebenfalls noch ein breites Gebiet mit über 35,0 ‰ Salzgehalt auf, aber es deutet sich in der Salzgehaltsverteilung und besonders im Isothermenverlauf schon eine Dreiteilung des atlantischen Stromes vor den drei Senken der Mittelschwelle an und zwar in 72°,

$73^1/_2°$ und $74^1/_2°$ n. Br. Ganz im Norden wurde in $76^1/_2°$ n. Br. über dem Ostabhang der Spitzbergenbank das kalte Bankwasser mit Temperaturen niedriger als —1° bis —1,6° und niedrigen Salzgehalten angetroffen. Durch eine Wiederholung des hydrographischen Schnittes auf 30° ö. Lg. im August—September 1927 in etwa vierwöchigem Zeitabstande liess sich die Veränderung innerhalb dieses Zeitraumes feststellen. Es zeigte sich, dass der Zustrom atlantischen Wassers erheblich zugenommen und seinen Einfluss auch mehr nach der Küste ausgedehnt hatte; parallel damit ging eine allgemeine Erhöhung des Sauerstoffgehaltes.

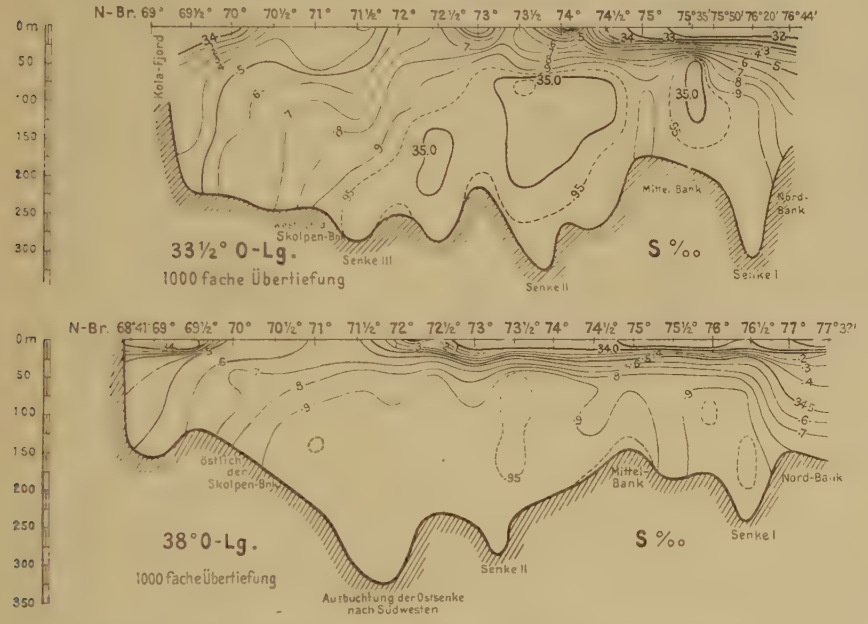


Abb. 11. Salzgehalt auf $33^1/_2$ und 38° O-Lg nach Beobachtungen des R.F.D. »Poseidon« im August 1927.

b. Das Gebiet der Mittelschwelle.

Die Region der Mittelschwelle ist das bislang am besten untersuchte Gebiet des Barentsmeeres, da auf dem Kolameridian ($33^1/_2°$ ö. Lg.) seit 1901 ziemlich regelmässig beobachtet worden ist. Als Grundlage der Betrachtung seien im folgenden insbesondere die im August 1926 und 1927 mit dem Fischereischutzboot »Zieten« und dem R. F. D. »Poseidon« auf $33^1/_2°$ und 38° ö. Lg. gewonnenen Schnitte benutzt, da sie für gleiche Monate von zwei auf einander folgenden Jahren eine vergleichende Betrachtung des ganzen Gebietes der Mittelschwelle bis sehr weit nördlich ermöglichen (vergl. Abb. 10 und 11). Sie führen in der Längsrichtung

über die Mittelschwelle hinweg und queren die Senken III, II, I (vergl. Abb. 1). Der Schnitt auf 38° ö. Lg. quert in etwa 72° n. Br. einen weit nach Südwesten vorspringenden Ausläufer der Ostsenke, der östlich der Mittelschwelle gelegenen Mulde.

Die westlich der Mittelschwelle von Westen nach Osten langsam zunehmende Unruhe des Verlaufes der Isothermen steigert sich über ihr erheblich und die auf 30° ö. Lg. sich bereits abzeichnenden Verzweigungen des Nordkapstromes sind hier klar entwickelt. Knipowitsch (17, 18) hat nach den älteren Beobachtungen auf dem Kolameridian die folgenden vier Zweige unterschieden: 1) Die erste Abzweigung — die Murmanströmung —, sie verläuft parallel der Murmanküste und

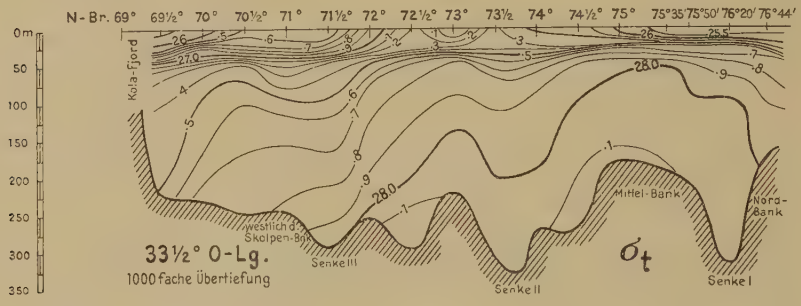


Abb. 12. Dichteverteilung auf $33^1/_3$°O-Lg nach Beobachtungen des R.F.D. »Poseidon» im August 1927.

das Temperaturmaximum wird gewöhnlich in $71^1/_2$° n. Br. angetroffen; 2) die zweite Abzweigung tritt unter $72^1/_2$° n. Br. auf nach einer kalten Zwischenschicht in 72° n. Br.; 3) die dritte Abzweigung unter $73^1/_2$° bis 74° Br., die von der zweiten durch eine kalte Zwischenschicht unter 73° Br. getrennt wird; 4) die vierte Abzweigung — die Franz Josephs Strömung — beginnt unter 75° Br. und wird von der dritten durch eine scharf bezeichnete kalte Zwischenschicht unter $74^1/_2$° n. Br. abgesondert. Diese Feststellungen sind durch die späteren Beobachtungen immer bestätigt worden, auch die von 1926 und 1927 tun dies, nur für die Franz Josephs Strömung scheint sich eine etwas nördlichere Lage zu ergeben. Auf 38° ö. Lg. sind diese Zweige der Nordkapströmung ebenfalls nachweisbar, sie treten in 71°, 72°, $73^1/_2$° und 76° bis $76^1/_2$° n. Br. auf.

Die Murmanströmung geht am Nordrande der Skolpen Bank entlang. Die südlich der Skolpen Bank auf $33^1/_2$° ö. Lg. in 70° Br. und auf 38° ö. Lg. in $68^3/_4$° Br. angetroffene verhältnismässig hohe Temperatur lässt auf eine südliche Abzweigung der Murmanströmung schliessen, die der tiefen Rinne an der Murmanküste, der sog. Südrinne, folgt. Diese Abzweigung wurde von Ruppin auch 1913 festgestellt, 1925 wurden

bis 35° ö. Lg. Anzeichen gefunden, auf 37° und 39° ö. Lg. dagegen nicht mehr (21, S. 117). Die zweite Abzweigung war über der ganzen Schwelle schwächer als gewöhnlich ausgebildet und war 1927 nur an einem verlangsamten Ansteigen der Isothermen kenntlich, während sie sich 1926 auf 33½° ö. Lg. kräftiger heraushob, auf 38° Lg. aber weniger als 1927 ausgebildet war. Die dritte und vierte Abzweigung heben sich im Isothermenbild in normaler Lage kräftig heraus. Nach Knipowitsch soll die Franz Josephs Strömung auf 33½° Lg. bereits unter 75° Br. beginnen, aber sowohl 1926 wie 1927 wurde in dieser Breite eine kalte Zwischenströmung angetroffen und die Franz Josephs Strömung begann erst in 75½° n. Br. Da diese nördlichere Lage auch nach der Bodengestaltung wahrscheinlicher ist und die übrigen Zweige der Nordkapströmung in diesen Jahren keine ungewöhnliche Lage haben, ist die Lage der Franz Josephs Strömung in Abb. 10 u. 11 als normal anzusehen. Die Franz Josephs Strömung wurde 1927 sowohl auf 33½° wie 38° ö. Lg. zum ersten Male völlig gequert und es wurde das nördlich befindliche kalte und salzärmere Wasser der Nordbank erreicht.

Die Salzgehaltsschnitte zeigen, dass das Wasser der Murmanströmung nicht rein atlantisch ist, es ist offenbar mit Bankwasser vermischt, der Salzgehalt beträgt 34,6 bis 34,8 ‰. Die drei nördlicheren Abzweigungen aber führten 1927 auf 33½° ö. Lg. Wasser mit über 35 ‰ und auf 38° ö. Lg. mit über 34,95 ‰. Die Höhe des Salzgehalts schwankt offenbar von Jahr zu Jahr stark, denn die dritte, die mächtigste Abzweigung wies 1926 auf 38° ö. Lg. den erheblich höheren Salzgehalt von 35,07 ‰ auf. Die Veränderungen, die 1927 auf 30° ö. Lg. innerhalb eines Monats festgestellt werden konnten, lassen vermuten, dass solche Schwankungen innerhalb kürzerer Zeiträume auch oberhalb der Mittelschwelle auftreten können, doch fehlt es an dem näheren Nachweis, da in kurzen Zeitabständen wiederholte Schnitte hier bisher nicht vorliegen. Ausser diesen unperiodischen Schwankungen des atlantischen Zustromes sind auch solche periodischer Natur vorhanden. Auf drei Dauerstationen (in 75°7′ Br., 26° Lg.; 73°30′ Br., 30° Lg.; 75°35′ Br., 33½° Lg.) wurde im August 1927 festgestellt, dass das atlantische Wasser an den untersuchten Punkten in Salzgehalt und Temperatur Schwankungen von ⅙- und besonders ½-tägiger Periode besitzt (29).

c. Das Gebiet der Spitzbergen- und Nordbank.

Die auf den nördlichsten Stationen auf 33½° und 38° ö. Lg. gewonnenen Beobachtungen ergaben, dass auf dem südlichen Teile der Nordbank die niedrigsten Temperaturen in 50 bis 75 m Tiefe vorhanden sind bei Salzgehalten von 34,4 bis 34,6 ‰. Es ist dies winterkaltes Wasser, das während der Eisbedeckung absinkt; unterlagert ist es sowohl auf 33½°

wie 38° ö. Lg. durch wärmeres mit höherem Salzgehalte, das der über die Senke I hinweggehenden Franz Josephs Strömung entstammt. Dies wurde am 21. Juli 1928 ebenfalls durch die »Malygin«-Beobachtungen festgestellt, die auf dem südöstlichen Abhange der Spitzbergenbank in 22° bis 25° ö. Lg. erfolgten. Wir dürfen annehmen, dass diese Unterlagerung durch wärmeres Wasser mit höherem Salzgehalte ausserhalb des Einflussbereiches der Franz Josephs Strömung nicht stattfindet und dort das kalte salzärmere Wasser bis auf den Boden reicht. Die 1927 auf 26° ö. Lg. auf der Spitzbergenbank gewonnenen Beobachtungen zeigen negative Temperaturen bis auf den Boden hin (Abb. 7), ebenfalls die von W. Brennecke (28) aus dem Juni 1923. Danach bilden die lange Zeit des Jahres vom Eise bedeckten flachen Meeresgebiete im Norden des Barentsmeeres in ausgesprochener Weise ein Kältereservoir. Der auf dem Schnitt in 19° ö. Lg. nördlich der Bären-Insel gequerte Teil der Spitzbergenbank liegt bereits auf deren atlantischer Abdachung und ist beeinflusst von dem Südspitzbergenstrom; negative Temperaturen wurden hier nicht festgestellt.

Ebenso wie das auf der Spitzbergenbank lagernde kalte vergleichsweise salzarme Wasser an deren südöstlichem Rande durch das warme Wasser der nördlichsten Abzweigung des Nordkapstromes unterlagert wird, ist es in entsprechender Weise auf der Nordabdachung der Bank nach dem Nordpolarbecken hin der Fall durch das warme salzreiche Wasser, das die tieferen Schichten des Nordpolarbeckens ausfüllt. Dies geht hervor aus einem mit dem Eisbrecher »Malygin« im Juli 1928 gewonnenen hydrographischen Schnitt von 79°0′ n. Br. 33°0′ ö. Lg. nach 77°32′ n. Br. 34°35′ ö. Lg. (38, S. 23). Die folgende, aus zwei nahe benachbarten Stationen kombinierte Beobachtungsreihe sei als Beleg angeführt.

Eisbrecher »Malygin« 13./14. Juli 1928.
78°47′/79°00′ n. Br. 33°35′/33°0′ ö. Lg.

Tiefe	t°C	S‰
0	—0,8	..
5	—1,57	33,86
10	—1,59	..
25	—1,70	..
50	—1,77	34,22
75	—1,69	..
100	—0,88	34,49
140	0,02	34,74
200	0,82	34,81
240	0,70	34,83

d. Die Ostmulde.

In der Ostmulde ist zur Zeit der Murman-Expedition wie auch in neuerer Zeit vom Wissenschaftlichen Meeresinstitut in Moskau vielfach gearbeitet worden (vgl. 19, Tafel), doch sind die neueren Beobachtungen erst unvollständig veröffentlicht, so dass wir im wesentlichen noch auf die älteren Beobachtungen angewiesen sind. Für das südöstlichste flache Gebiet liegt dagegen eine neuere Bearbeitung vor (22).

Danach kann man die Ostmulde und auch den flachen Südosten als ein Kältereservoir des Barentsmeeres bezeichnen. Unterhalb einer oberen Schicht von 25 m Mächtigkeit mit sommerlich erwärmtem Wasser herrschen negative Temperaturen vor, die bis zum Boden auf unter —1,5° abnehmen, wie es auch der auf 38° ö. Lg. gequerte südöstliche Zipfel der Ostmulde erkennen lässt (Abb. 10). Der Salzgehalt dieses Wassers ist etwa 34,9 ‰. 1902 wurde unter 75° Br. am Boden der Mulde eine dünne Schicht mit über 35,0 ‰ festgestellt. In dieses kalte Wasser sind in 100 bis 200 m Tiefe einzelne Gebiete wärmeren Wassers mit Temperaturen über 0,0° und gegen die Umgebung etwas erhöhtem Salzgehalt eingeschaltet (vergl. z. B. 18, Tafel VI; 8, Tafel XX, XXI). Dies sind Fortsetzungen der über der Mittelschwelle festgestellten Verzweigungen des Nordkapstromes. Knipowitsch hat von diesen festgestellt: eine südliche Abzweigung der Murmanströmung, die nördlich von Kap Kanin in Richtung auf Kolgujew vorbeiführt und deren Verlauf anscheinend durch die Ausbuchtung der 200 und 100 m-Linie nach Osten stark beeinflusst ist (vergl. Abb. 1), einen nördlichen an der 200 m-Linie entlang führenden Zweig, der sich weiterhin abermals teilt in einen ostsüdöstlichen Arm, die Kolgujew Nowaja Semlja-Strömung, und einen zunächst nordöstlichen, dann nördlichen Arm, die warme Nowaja Semlja-Strömung. Weiterhin weisen auch die übrigen Zweige der Nordkapströmung in dem Gebiet der Ostmulde nach Norden umbiegende Fortsetzungen auf.

Das kalte Wasser der Ostmulde mit vergleichsweise hohen Salzgehalten von 34,9 bis 35,0 ‰ ist ohne Zweifel eine winterliche Bildung und entsteht zur Zeit der weit nach Süden reichenden Eisbedeckung durch Abkühlung des aus dem Westen vordringenden atlantischen Wassers. Dies geschieht vielleicht oder wahrscheinlich garnicht einmal direkt über der Ostmulde, sondern in der östlichen Westmulde und über der Mittelschwelle, bis wohin das Wasser mit diesen hohen Salzgehalten auch oberflächlich gelangt. Es wäre denkbar, dass in Jahren weit reichender Eisbedeckung Wasser mit höherem Salzgehalt bis nahe dem Gefrierpunkt abgekühlt wird und nach Osten absinkt als in extrem milden Jahren. Dann könnte sich eine Schichtung kalter Wassermassen mit verschieden hohen Salzgehalten herausbilden, deren Durchlüftungs-

zustand einen Schluss auf die seit dem Absinken verflossene Zeit gestatten würde. Es sind aber bislang keine Beobachtungen nach dieser Richtung bekannt. Da die Schicht kalten salzreichen Wassers sich bis über das Niveau der Mittelschwelle erhebt, gelangt es, wie die Beobachtungen über der Mittelschwelle und in der Westmulde zeigen, über diese Schwelle hinweg nach Westen und bildet die Ursache für die dort am Boden und

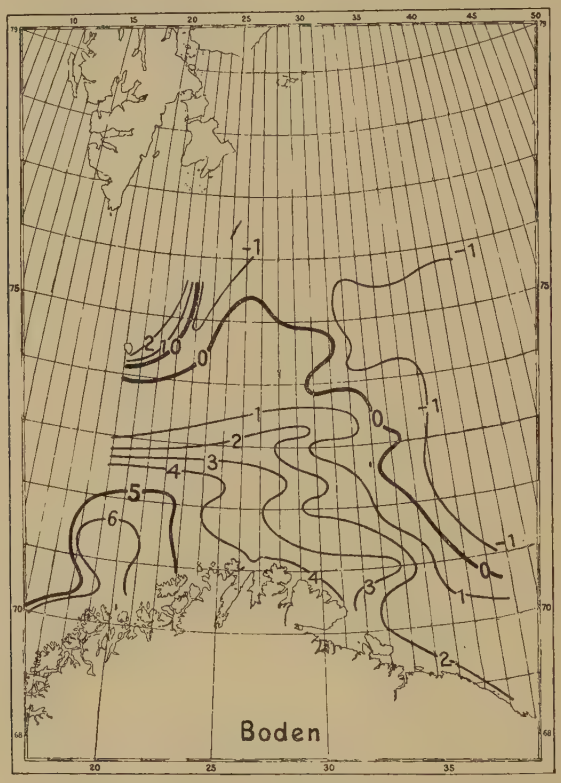


Abb. 13. Temperatur des Bodenwassers im westlichen Barentsmeere im August—September 1927.

zwischen den Armen der Nordkapströmung festgestellten niedrigen Temperaturen. Nach Westen steigen die Temperaturen, aber auch die Salzgehalte nehmen zu (vergl. Abb. 7, 8, 10, 11 sowie 13 und 14).

e. Der flache Südosten und das Weisse Meer.

In dem ausgedehnten flachen Südosten des Barentsmeeres lagert unter einer salzärmeren, sommerlich erwärmten Deckschicht winterkaltes Wasser mit Temperaturen bis —1,8° und nach Südosten, parallel

mit der Verflachung des Meeres abnehmenden Salzgehalten zwischen 35 und 34 ‰. Die Deckschicht reicht in Nähe der Insel Kolgujew etwa bis 75 m Tiefe und vor der Karischen Strasse nur bis etwa 25 m. Zu der im ganzen Gebiet wirksamen oberflächlichen Aussüssung durch das Schmelzwasser kommt im Südosten noch die Wirkung des Süsswasserabflusses der Petschora hinzu und in der Nähe der Zugänge zur Kara

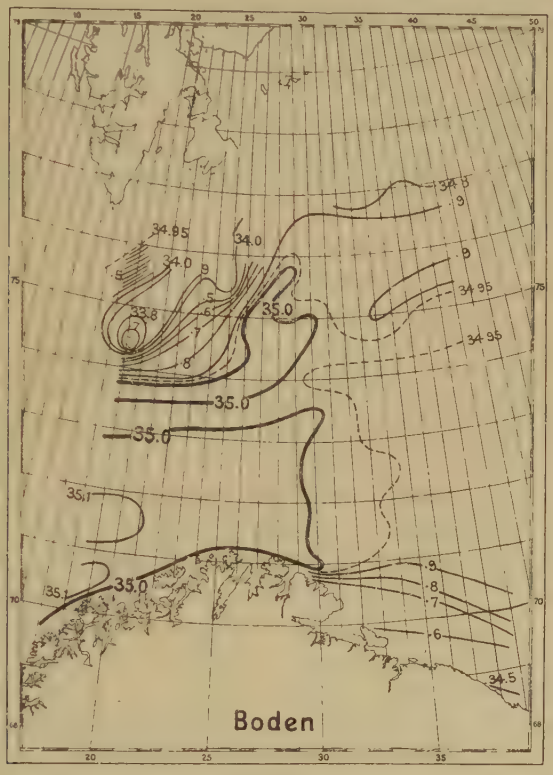


Abb. 14. Salzgehalt des Bodenwassers im westlichen Barentsmeere im August—September 1927.

See der Zufluss kalten Wassers aus der Kara See (22, 8 Tafel XXIII). Im Südwesten, vor dem Eingang zum Weissen Meere treten negative Temperaturen im Sommer nicht mehr auf. In der mit der Linie Swatoi Noss—Kap Kanin beginnenden und nach dem Weissen Meere hinführenden südwestlichen Bucht des Barentsmeeres, der sog. Woronka, und noch mehr im Gorlo selbst, ist das Wasser infolge der Vorgänge des Wasseraustausches stark durchmischt und bis auf den Boden durchwärmt (14 a, 14 b, 31). Im Gorlo wurde im August 1922 von der Ober-

fläche bis zum Boden auf 7,5° bis 8,0° erwärmtes Wasser angetroffen mit geringen Salzgehaltsunterschieden. Im Weissen Meere selbst lagert unter einer 25 bis 50 m mächtigen sommerwarmen Deckschicht mit 20 bis 27 $^0/_{00}$ Salzgehalt kaltes und salzreicheres Wasser. Bis nach dem Boden hin nimmt die Temperatur bis —1,4° ab, der Salzgehalt beträgt dort $29^1/_2$ bis $30^1/_2\,^0/_{00}$. Dieses Wasser ist gut durchlüftet, sodass es offenbar häufiger erneuert wird. Die Zufuhr frischen Wassers in die Tiefenregion des Weissen Meeres kann in anbetracht der niedrigen Oberflächensalzgehalte nicht im Weissen Meere selbst erfolgen, sondern geschieht über die vom Barentsmeer trennende Schwelle hinweg, wenn im Winter in der Woronka Abkühlung bis auf den Gefrierpunkt erfolgt. Dieser Vorgang ist ähnlich der Erneuerung des Tiefenwassers im Bottnischen Meerbusen aus den westlicher gelegenen Gebieten mit höheren Oberflächensalzgehalten.

f. Die Rinne zwischen Franz Josephs Land und Nowaja Semlja.

Die tiefe Ostmulde ist durch eine sich erheblich über 300 m erhebende Schwelle von der mehr als 300 m tiefen Rinne zwischen Franz Josephs Land und Nowaja Semlja abgetrennt. Ein Austausch mit dem Nordpolarbecken kann also erst oberhalb dieser Schwelle stattfinden. Wir besitzen nur wenig Beobachtungen aus diesem Gebiete. Drei Schnitte sind im August 1901 gewonnen worden (18, Tafel VI), die neueren Beobachtungen vom Institut zur Erforschung des Nordens in Leningrad sind noch nicht veröffentlicht (15). Die obere Wasserschicht wird im Sommer z. T. bis über 0° erwärmt. Von etwa 25 bis 150 m Tiefe aber herrschen niedrige Temperaturen vor von unter —1,5° und Salzgehalten von etwa 34,6 $^0/_{00}$. In grösserer Tiefe, von etwa 250 m Tiefe ab, lagert Wasser mit höheren Temperaturen und 34,9 $^0/_{00}$ Salzgehalt. Hier herrscht also bereits der Typus vor, der für das Nordpolarbecken charakteristisch ist. Am reinsten ist dies bei dem östlichsten der drei Schnitte der Fall, so dass also die tiefe Rinne zwischen Franz Josephs Land und Nowaja Semlja in ihrem Verlaufe überleitet zu den hydrographischen Verhältnissen des Nordpolarbeckens.

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The Snellius Expedition.

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Since 27th July 1929 a Dutch deep-sea expedition has been engaged in the investigation of the inland seas between Asia and Australia, especially the deep basins in the eastern part of the East Indian Archipelago. This expedition was initiated by the Society for Scientific Research in the Dutch Colonies and the Royal Geographical Society at Amsterdam, with substantial aid from the Government both in Holland and in the Colony. These Governments lent the vessel, H. M.S. "Willebrord Snellius", met the cost of crew and maintenance during the cruise, and contributed towards the funds, one half being supplied privately. The Leader of the expedition is Commander P. M. van Riel, Chief of the Oceanographical Department, Royal Dutch Meteorological Institute. The scientific staff further consists of Dr. H. J. Hardon and H. C. Hamaker (oceanography), Dr. A. B. Boelman (chemistry), Dr. Ph. H. Kuenen (geology), Dr. H. Boschma (biology), while Commander F. Pinke and his officers take charge of echo-soundings, determine positions and some of the crew aid in laboratory work. It was a happy coincidence that the expedition was simultaneous with the gravity expedition on submarines of Prof. Vening Meinesz, which supplied much additional information on the configuration of the sea bottom and indicated localities of special interest, receiving in turn useful information from the Snellius expedition.

The reports received, partly published in the "Tijdschrift Aardrijkskundig Genootschap", cover the first year of the expedition. On August 12th, 1930, the Snellius entered upon the final quarter. Figs. 1, 2 and 3 give an idea of the track and the number of oceanographic stations, which already surpass 300, the total number of salinity determinations

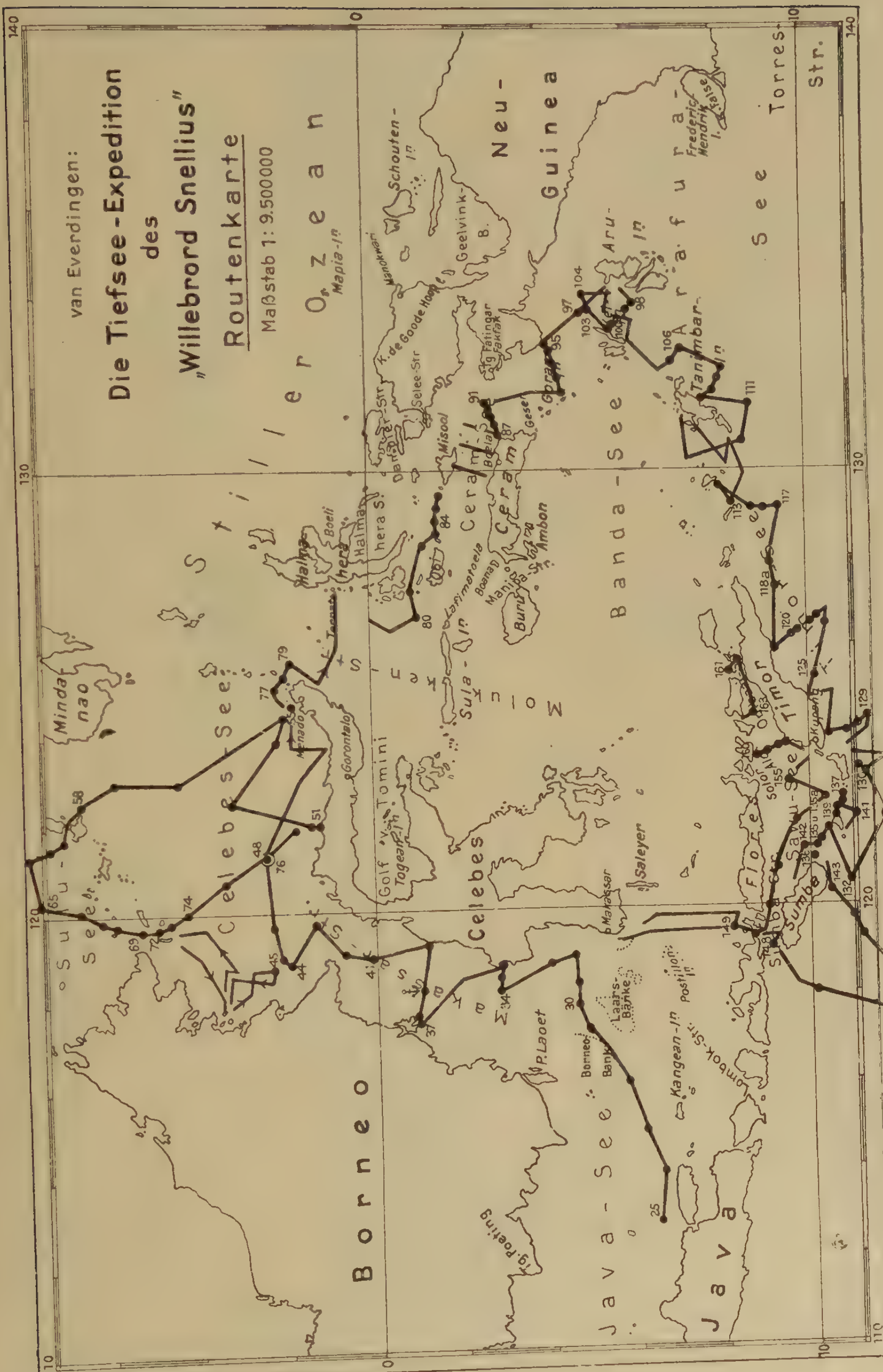
van Everdingen:
Die Tiefsee-Expedition
des
„Willebrord Snellius"
Routenkarte
Maßstab 1: 9.500000
Stiller Ozean
Mapia-In
Schouten-In
Neu-Guinea
Geelvink-B.
Halmahera
Celebes-See
Sulu-See
Mindanao
Borneo
Celebes
Molukken-S.
Sula-In
Ceram
Ambon
Buru
Misool
Banda-See
Aru-In
Arafura-See
Tanimbar-In
Timor
Flores
Sawu-See
Sumba
Java-See
Java
Saleyer
Makassar
Kangean-In
Postillon-In
Lombok-Str.
Torres-Str.
Frederic Hendrik I.
Golf v. Tomini
Togean-In
Gorontalo
Menado
P. Laoet
Borneo-Bank
Laars-Bänke
Selee-Str
Dampier-Str
Kai-In
Manipa
Boano
Kelang
Obi
Ternate
Tg Poeting
110
120
130
140
0
10

Fig. 1.

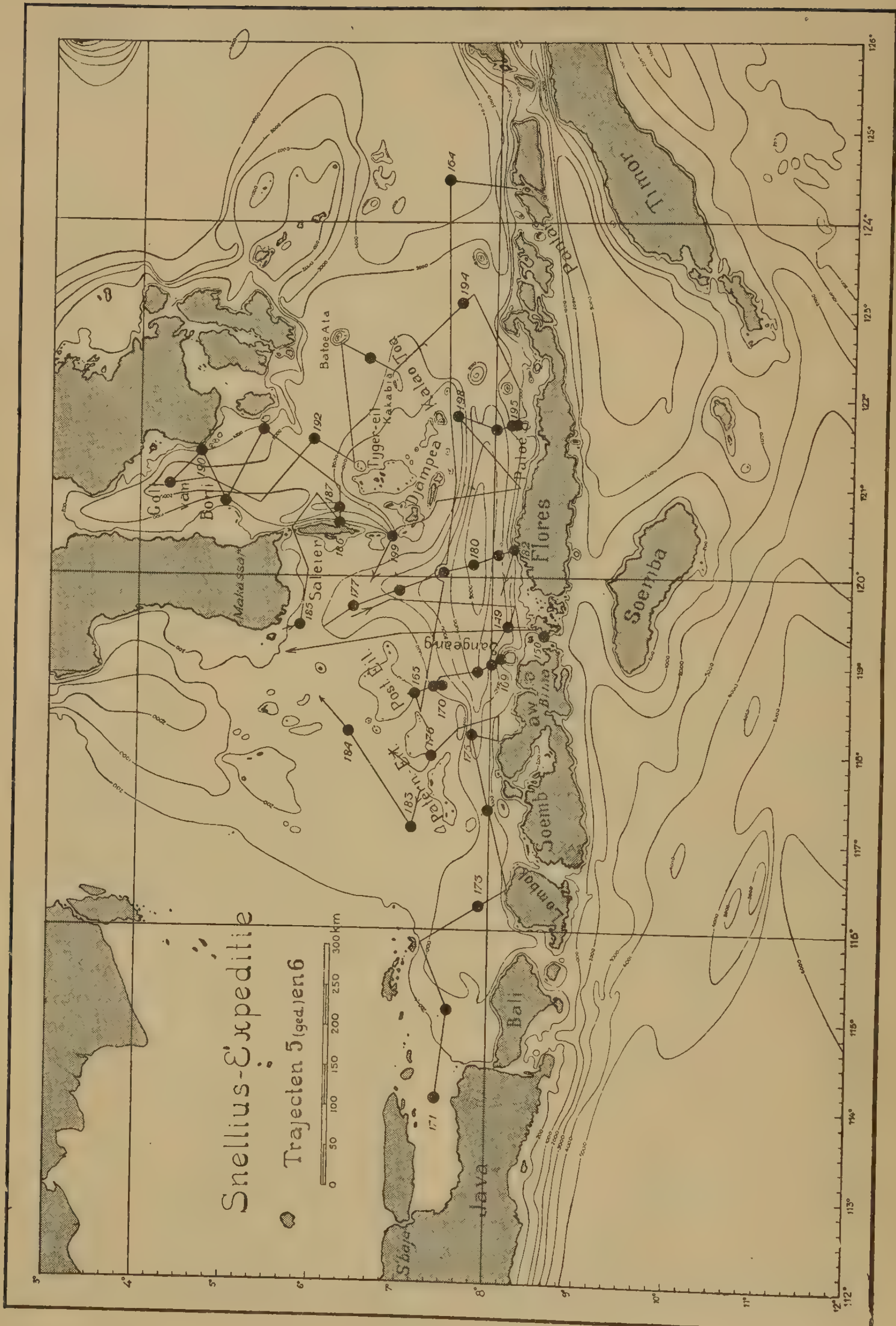
Snellius-Expeditie
Trajecten 5 (ged.) en 6
300 km
Java
Bali
Lombok
Soemba
Flores
Soemba
Timor
Makassar
Saleier
Djampea
Kalao
Batoe Ata
Boni
Dangeang

Fig. 2.

Snellius-Expeditie
Maart-April 1930
Ceram
Ceram-zee
Boeroe
Obi
Wetar
Makassar
Boeton
Saleier
Komba
Batoe Ata
Banda Zee
Soela
Taliaboe
Mangol

Fig. 3.

being probably more than 15,000. In general the expedition has been very successful; loss of instruments occurred less than might have been expected, and it looks as if the programme fixed beforehand will be carried out with only small reductions not affecting the main lines.

The principal object of the expedition was the accurate determination of the configuration of the deep basins and the intervening ridges, bottom deposits, especially with a view to geological problems, and the investigation of the physical and chemical properties of the sea water, its horizontal and vertical circulation, the distribution of the plankton and such other geological and biological problems as can be solved without endangering the main oceanographic programme, including visits by the geologist and biologist to coral islands.

It will only be possible after the return of the expedition and after investigation of the data accumulated to judge of the importance of the results, but some preliminary results indicate that our knowledge of the East Indian Archipelago will be much increased.

Configuration of the bottom. In general also this expedition has confirmed the view that the configuration of the sea-bottom is much more complicated than was assumed formerly; the bottom of the Celebes sea only is very smooth below 5000 m. Very steep gradients were found, for instance, in the neighbourhood of Maratua (NE. Borneo), where differences of 5000 m. in depth are found at places only a few dozen miles apart. A sounding at station 145 (119°15′ E, 11°10′ S) gave 6300 m. instead of 5000 m. as shown on the map, indicating that probably the Java and Timor deeps form a continuous depression. The "nose" of Borneo near Tg. Mangkalihat continues as a submarine ridge at about 1000 m. until halfway to Celebes; at one spot 600 m. was found, where the map indicated 2000. The exact depths of many "thresholds" were determined in order to elucidate the temperatures and the circulation. Gravity determinations by Vening Meinesz indicated a possible continuation of the inner Banda ridge towards Sanana, and the soundings confirmed this by detecting a ridge at 3000 m. Several meridional ridges were found in the Molukkian Sea. The Aru and Ceram deeps are parts of one continuous deep, the latter being limited towards the South by a threshold at 1600 m.

In the Banda Sea a new ridge, NE—SW, south of the Lucipara islands is mentioned with a minimum depth of 3100 m. and isolated prominences of 900 and 850 m. south of Ambon and Buru. Southwest of the Sulu islands, folding is suspected in a direction NE—SW, the maximum depth ± 5800 m. being considerably lower than on existing maps.

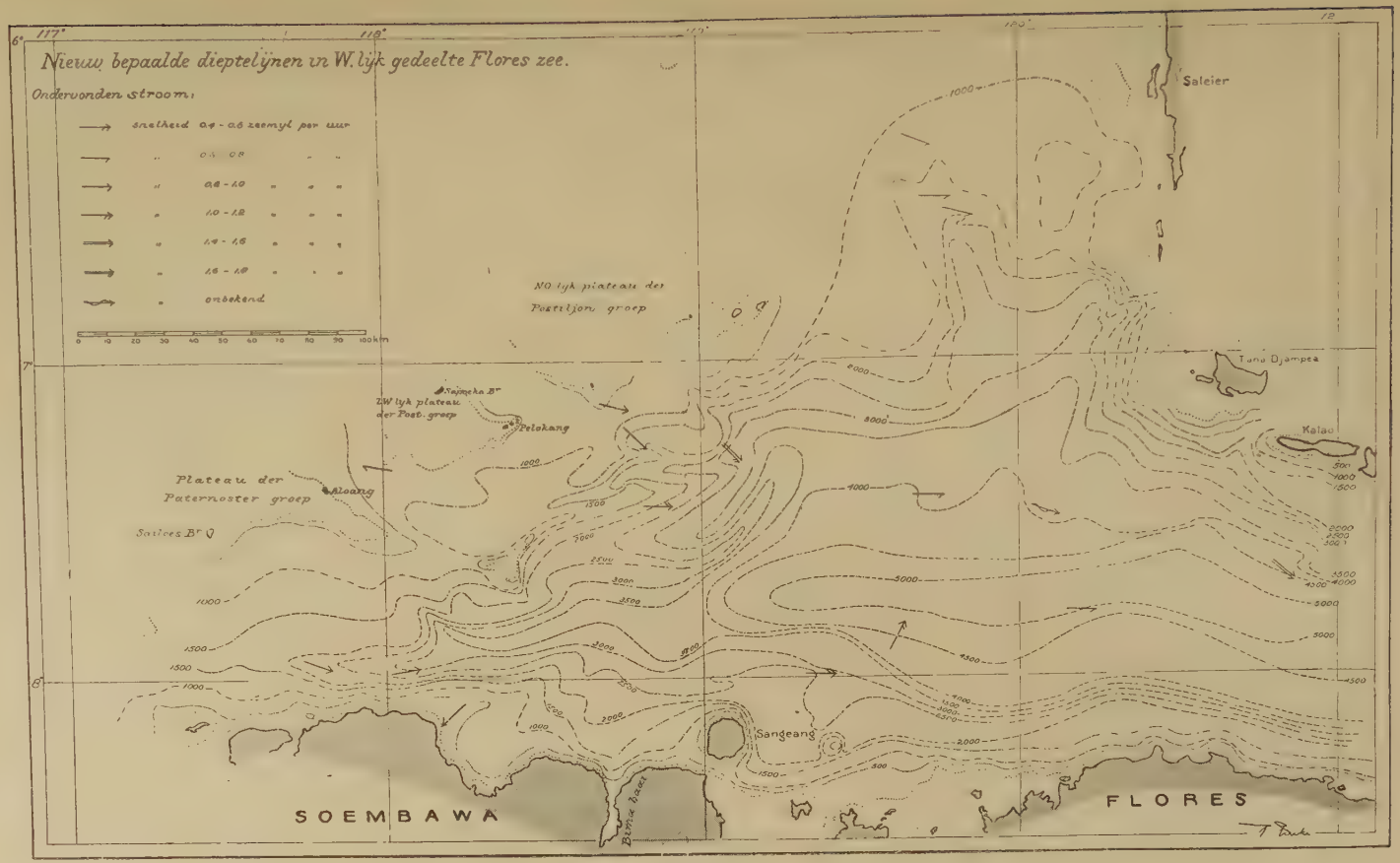
Nieuw bepaalde dieptelijnen in W. lijk gedeelte Flores zee.
Ondervonden stroom:
snelheid 0.4 - 0.6 zeemyl per uur
0.6 - 0.8
0.8 - 1.0
1.0 - 1.2
1.2 - 1.4
1.4 - 1.6
1.6 - 1.8
onbekend
0 10 20 30 40 50 60 70 80 90 100 km
NO lijk plateau der Postiljon groep
ZW lijk plateau der Post. groep
Plateau der Paternoster groep
Pelokang
Aloang
Saleier
Tana Djampea
Kalao
Sangeang
SOEMBAWA
FLORES
Bima baai

Fig. 4.

As an example of the many details of the configuration which it is now possible to draw on a map, we reproduce here fig. 4, constructed by Commander F. PINKE from the complete material for the Flores Sea, and indicating at the same time currents during the west monsoon. The bottom configuration is quite different from what existing geological views lead one to expect.

Temperature and salinity. At the stations 15 water samples were taken between the surface and 1000 m., with further ones for each 500 m. In the deep basins closed by "thresholds" a rise of temperature is always observed below a certain level, but this rise is only according to the calculated adiabatic gradient in the lowest strata, and the influence of mixing causes the minimum temperature to occur considerably below the level of the threshold; for instance, in the Sulu Sea (threshold 270 m.) at 500 m. 11.00°, at 1100 m. 10.07° (minimum), at 4400 m. 10.51°. The table below gives in thousandths of a degree the increase in temperature below the depth of minimum temperature between the levels indicated.

	Min. temp.	Depth	Depth increased by						
	°C.	m.	250	750	1250	1750	2250	2750	3250
Sulu basin	10.07	1100	15	40	60	65	75	85	90
Celebes basin.....	3.58	2500	5	25	45	65	70	..	..
Java deep	1.17	4300	10	45	55	..	..	..	..

According to a cablegram the lowest temperature in the Mindanao deep was 1.56° at 3500 m., the bottom-temperature below 10,000 m. being 2.47°.

Fig. 5 gives the distribution of minimum temperatures in the various basins and deeps.

Generally a lower minimum temperature implies a higher salinity of the bottom water layer. The following figures illustrate this.

Mindanao deep	34.70—34.66	Java deep	34.72—34.70
Celebes basin.....	34.60—35.54	Timor deep	34.69
Sulu basin	34.49—34.45	Aru basin.....	34.65—34.61

In general the results of the salinity determinations have not yet been plotted; in one case, however, in a vertical section through the Timor deep, the slope of isohalines and isotherms towards the bottom indicates that the water of maximum salinity and lowest temperature did not penetrate far into the deep. The oxygen content has a maximum here at 100 m. over the threshold. All these phenomena point to mixing.

Also the calculation of currents from the densities has not yet been tried in many cases. In the Timor deep the calculation indicated a current between 150 and 250 m. depth towards SE., lying between currents to the W. at the surface and further down.

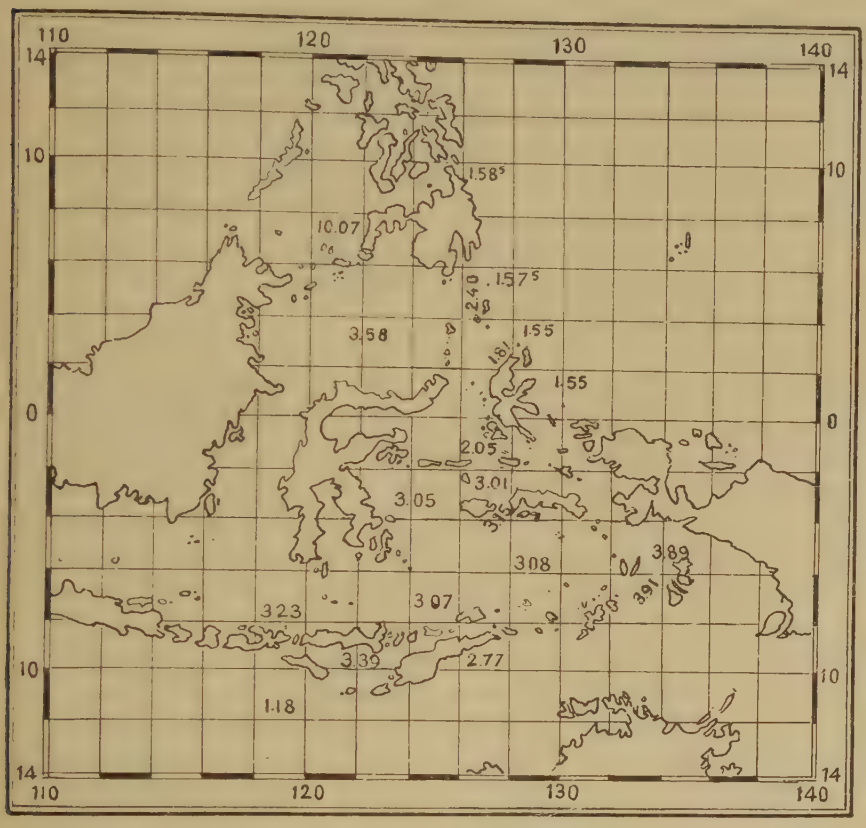

Fig. 5.

Thousands of oxygen determinations have proved of much value in the study of the currents; lack of circulation is indicated by very low oxygen contents in the Sulu sea, in places not more than 2 cc/l. The minimum, which in the open ocean is usually found at 600 m, occurs at various depths in the basins; these depths depend in the same way on the depth of the threshold as that of the minimum temperature.

Current-measurements. Extensive measurements of currents were made in various passages between two basins, extending to 1900 m. depth in Makasser strait, to 1000 m. in Sawu strait, to 1700 m. in the passage between Mangoli and Obi; the measurements were continued

for more than 24 hours, so as to show tidal movements as well as residual currents. In Makasser strait, the strongest current was 83 cm/sec. SSE. at 50 m. depth, as compared with 30 cm. SE. at the surface. At the bottom a very weak current to the N. was found. In Sawu strait tidal influences were evident down to 1000 m.; the residual currents, 30 cm. at the surface, 8 cm. at 50 and 200 m., was 17 at 100 m. and 11 at 1000 m., with very different directions, whereas near the bottom a current of 19 cm/sec appeared strong enough to prevent any deposits.

Near Obi, the residual current had a component towards the North between the surface and 200 m., towards the South at 350 and 500 m. At 1500 m. depth, the current changed in 5 hours from 30 cm/sec. SE. to 17 cm. NW. The residual current is 6 cm/sec. towards SE. Near the bottom, fluctuations of temperature indicated also changeable currents, probably of a turbulent type.

Fluctuations in physical and chemical properties of the sea water. In Makasser strait, Sawu strait and near Obi (station 253a) water samples were taken every two hours for 24 hours at depths extending to 500 or 800 m. Temperature, salinity and oxygen-content showed parallel fluctuations, indicating probably internal waves with a maximum amplitude of 100 m. at station 253a (depth 450 m.), and of 40 m. in Makasser strait (depth 250 m.). In comparison we mention an amplitude of about 20 m. found by DEFANT in the Atlantic Ocean.

Bottom deposits. In addition to the ordinary bottom samples taken during the soundings a special tube of 4 m. length was constructed in order to obtain very long samples of bottom deposits. This device has been very successful, as, for instance, on the slope of the Sabu shelf samples of 102 cm., in the Gulf of Boni even of 174 cm. were obtained, a remarkable length. During the extension of the cruise towards the Mindanao deep a bottom sample of red sea clay of 54 cm. was obtained at a depth of more than 10,000 m., the maximum depth measured by echo sounding being 10,170 m. The most interesting result of the study of the bottom samples is that in the Sulu sea in depths over 4000 m. at stations 64, 65 and 66 deposits appeared to consist mainly of globigerines. This may point to a very slow circulation, but also the alkalinity and p_H may give an explanation, as the former is lower and the latter higher in the Sulu sea, so as to diminish the rate of solution of the calcium carbonate.

We must abstain from mentioning here results bearing on geology and biology; the preliminary reports, however, show that many facts are being collected and that in these respects also important contributions to our knowledge of this interesting area may be expected.

Seasonal Changes in the Phosphate and Nitrate Content and in Hydrogen Ion Concentration in the Barents Sea.

By

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Murman Station of the Oceanographic Institute, Moscow.

The Murman Biological Station[1]) has for many years been conducting systematic hydrographic and biological researches in the Barents Sea. The investigations have been carried out on periodical cruises along the meridians 33°30′ E., and 38° E., from the Murman shore up to the ice margin. The cruises are made four times a year in March, May, September and December, the stations being 30 miles apart. At each station physical and chemical conditions are investigated, plankton collected, and the bottom fauna studied by means of trawls and dredges.

From the spring of 1929 the determination of nutrient salts (phosphates, nitrates, nitrites and silicates), which proved to be a factor potent in their effect upon marine life, was included in the programme of chemical investigations.

As far as the authors know, observations concerning changes in nutrient salts in the sea water of polar regions throughout the whole year have not yet been published. The present paper is a brief report on the seasonal variations in phosphates and nitrates in the central part of the Barents Sea. This represents only a part of the work on hydrography, chemistry, bottom deposits, fertility and biology of the Barents Sea, which is carried out nowadays by the State Oceanographic Institute.

The observations reported below were made on board the "Nikolai Knipovitch", a 100 ton sailing-motor ship, built for the Murman Station in Norway in 1928.

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[1]) In autumn 1929 the Murman Biological Station (at Alexandrovsk, Murman coast) was united with the Maritime Scientific Institute, Moscow, and became a joint Oceanographic Institute.

The determinations of phosphates were carried out on board by the colorimetric method of Atkins. For the colour comparison a set of Heyners cylinders of 40 cm. length was used. These cylinders were fixed on a stand, and it was possible to compare simultaneously the depth of colour of several samples of water with that of the standard.

The nitrate estimations were carried out on shore, by the colorimetric method of Harvey, using a Duboscq colorimeter, the sea water samples having been preserved by the addition of mercuric chloride.

The hydrogen ion concentration was determined on board by the indicator method, using cresol red and thymol blue as indicators and borax-boric acid standard buffer solutions differing from one another by 0.1 pH.

The measurements of phosphate content reported here are given without any correction for salt error. The pH measurements are corrected, the correction for salt error being — 0.20.

The data dealt with here are given in tables and diagrams. The phosphate data represent mg of P_2O_5 per cubic metre, the nitrate data mg of nitrate + nitrite N_2 per c.m. Besides the distribution of phosphates, nitrates and pH, a picture of temperature distribution is also given, as it is quite necessary in order to get a clear understanding of the peculiarities of the physical and chemical conditions of the sea area studied[1]).

As is well known, a drift of Atlantic water flows round the North Cape into the Barents Sea. This drift of water, generally called the North Cape current, is divided into several branches; the southernmost, moving along the Murman coast, is known as the Murman current. The northern one, which crosses the Kola meridian at lat. 75°—76° N., is known as the Franz-Joseph branch.

During our cruises along the meridians we have alternately traversed the regions of warm water of Atlantic origin and the areas of cold Arctic water. The sea along the meridian 38° E. differs from that along the more western Kola meridian (33°30′ E.) by reason of a diminution in the quantity of Atlantic water and a predominance of cold Arctic waters.

Fluctuations in the inflow of oceanic water into the Barents Sea occur from year to year; consequently there occur fluctuations in the general physical conditions in the Barents Sea.

The year 1929 was distinguished by an uncommon diminution in the inflow of Atlantic water into the Barents Sea. The cold Arctic waters

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[1]) A full account of the results of the investigations in the Barents Sea is in press in the Reports of the State Oceanographical Institute (Russian).

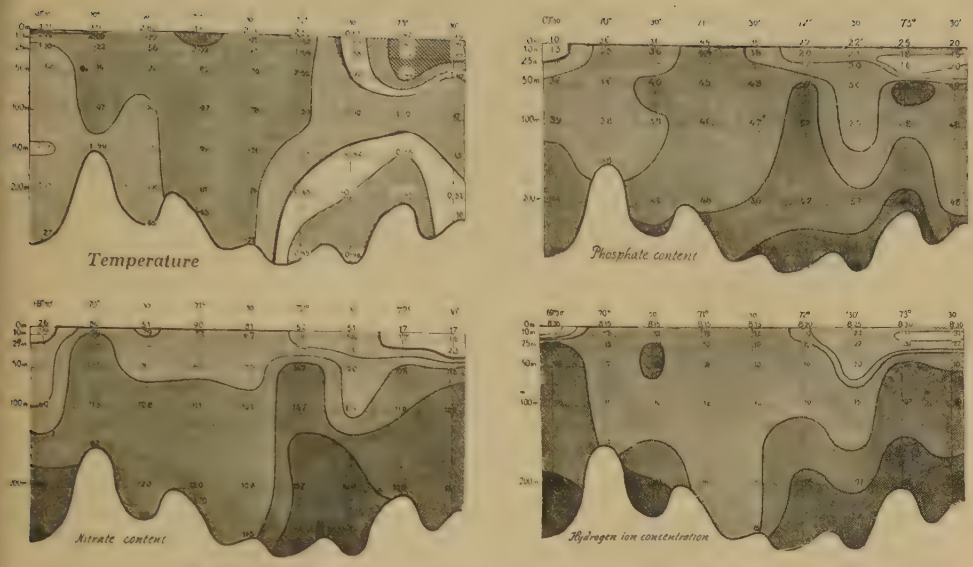


Fig. 1. Temperature, phosphate and nitrate content and hydrogen ion concentration along the Kola-meridian, long. 33°30′ E. May 15—19 1929.

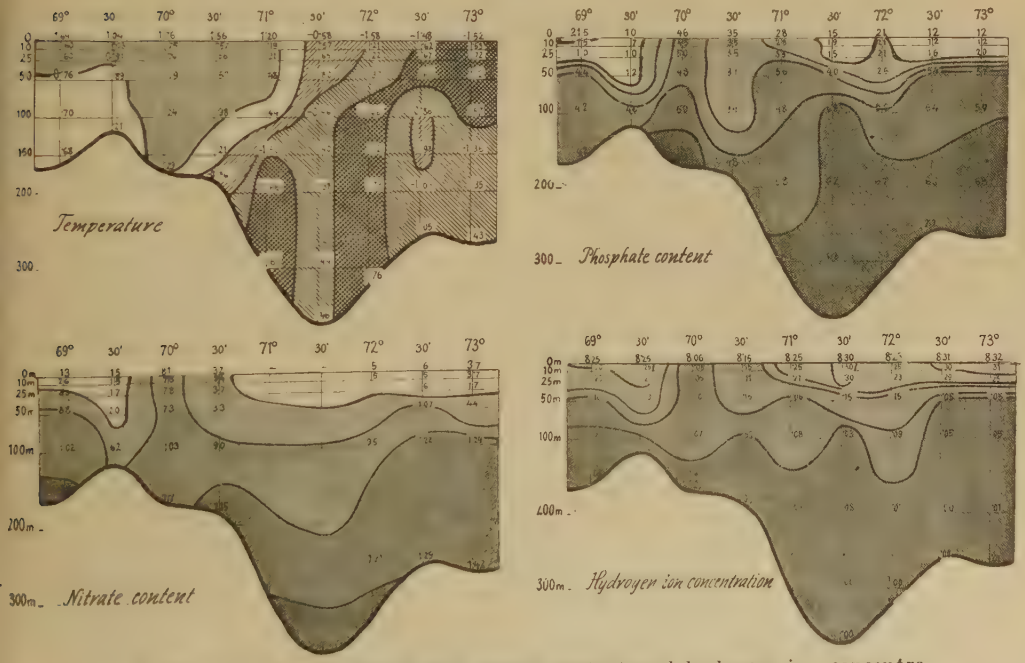


Fig. 2. Temperature, phosphate and nitrate content and hydrogen ion concentration along the meridian long. 38° E. May 26—28 1929.

advanced far towards the south and, correspondingly, the ice margin was very close off shore. The cruises in May 1929, therefore, were very short; they reached only as far as lat. 73°30′ N. along the Kola meridian and as far as lat. 73° N. along long. 38° E. The results of the May sections are shown on diagrams Figs. 1 and 2.

These diagrams show that the deep water contains an rich store of phosphates and nitrates. The upper layers, especially from the surface down to the 25 metre level, show a diminution in the content of these salts.

As the nutrient salts in the sea are used up by the phyto-plankton, and as the activity of the algae takes place only where light can penetrate with sufficient intensity, such a distribution of phosphates and nitrates is quite natural.

But the distribution of phosphates and nitrates is not uniform everywhere along the meridians. On the Kola meridian we may perceive a wide band in the region of lat. 70°—71° N. and on the eastern meridian (long. 38°) a narrower band near lat. 70° N. — with a different vertical distribution of phosphates and nitrates.

In these places the deep water contains nearly the same quantity of nutrient salts as the surface layer. The vertical distribution is quite uniform. The upper layers are relatively rich in phosphates and nitrates as compared to the neighbouring regions of the sea, and the store of these salts in the bottom water is not so abundant here as there.

If the peculiarity in the distribution of phosphates and nitrates depends upon the phytoplanktonic activity, the dissolved oxygen and the hydrogen ion concentration must show an analogous distribution, because the oxygen pressure and hydrogen ion concentration in the upper strata of the sea are also determined by plant life. The diagrams show a complete analogy between the distribution of pH and that of phosphates and nitrates along both the meridians. The same distribution was also observed for the dissolved oxygen.

The water in the upper strata is more alkaline (pH 8.3—8.2); in the depth the reaction becomes more acid (pH 8.0—8.1). The districts with a uniform vertical distribution of phosphates and nitrates are also distinguished by equal hydrogen ion concentration from bottom to surface.

If our considerations are correct, we have to expect that at the stations lat. 70° and 71° N. along the Kola meridian, and the station lat. 70° N. on the meridian 38° E. the plant life must be very scarce.

Indeed, the samples of plankton, quantitatively collected, show an absolute absence of green coloured matter on these stations, even in the

upper 25 metres, whereas the waters close inshore, and the more northern ones, were exceedingly rich in phytoplankton in May. The diatoms and dinoflagellates were so numerous that they clogged the plankton nets and made the work of collecting plankton very troublesome.

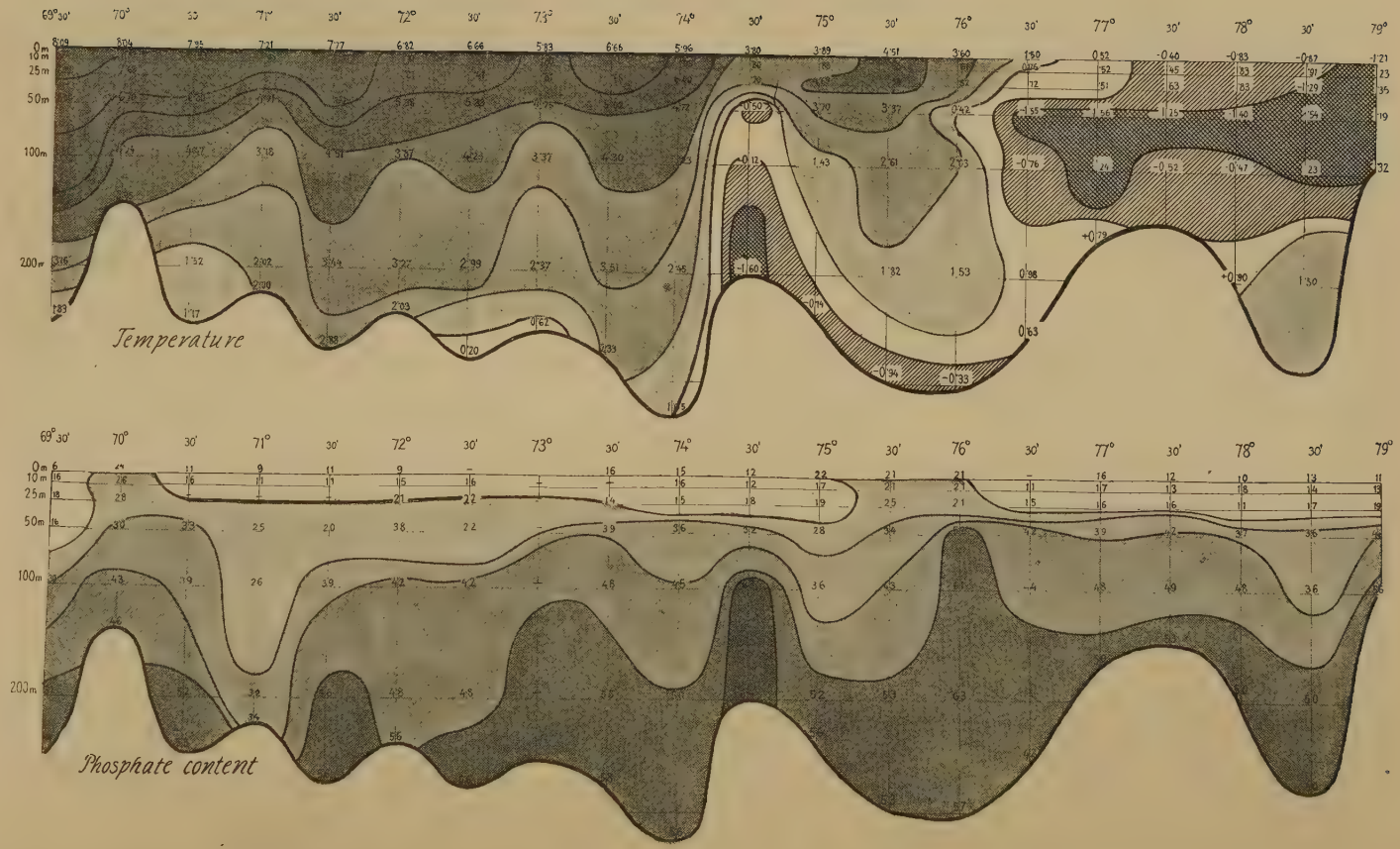
In order to get a quantitative evaluation of the relative amounts of plankton flora at different positions each of the plankton samples, which were collected from the upper 25 metres[1]), was well stirred in one litre of sea water, and aliquot parts (ca. 25 cm.) of them were pipetted into centrifuge tubes. The aliquot parts were centrifugalised, the water decanted, and the residue extracted with 4 ccm. of 96 % alcohol. The chlorophyll content in the alcoholic extracts, which also contained other pigments, was determined spectrophotometrically in absolute units; the results obtained are shown in Table 1.

Table 1. Chlorophyll content in the upper 25 metres and of nutrient salts in the upper 10 metres Kola meridian (long. 33°30′ E.) May, 1929.

Position	69°30′	70°	70°30′	71°	71°30′	72°	72°30′	73°	73°30′
P_2O_5 ..... mg. per cu. m.	12	36	36	44	38	21	21	21	17
Nitrate N_2 .. mg. per cu. m.	27	90	65	81	74	54	53	17	16
Chlorophyll . mg. per cu. m.	12×10^{-2}	0	0	0	0	6.5×10^{-2}	8.2×10^{-2}	1.8×10^{-2}	4.1×10^{-2}

What is the reason of such a difference in the quantity of phytoplankton at various positions, situated relatively near one another? A comparison with the temperature shows us that the regions devoid of phytoplankton are those with water of maximal temperature. They correspond to the southern part of the Atlantic stream, the so-called Murman current. Thus the warmer Atlantic waters in May differ from the cold Arctic waters of the Barents Sea by reason of a nearly complete absence of plant life, and consequently with a uniform vertical distribution of nutrient salts, and of hydrogen ion concentration. The vernal outburst of algal growth takes place only in the cold Arctic waters and here causes a depletion of nutrient salts in the upper layers, concurrently with a rise in pH and dissolved oxygen. We cannot give a thorough explanation of it as yet. Perhaps the waters of western origin, coming from the

[1]) Plankton net, 50 cm. diameter, bolting silk Nr. 25.


69°30'
70°
30'
71°
30'
72°
30'
73°
30'
74°
30'
75°
30'
76°
30'
77°
30'
78°
30'
79°
0m
10m
25m
50m
100m
200m
Temperature
Phosphate content

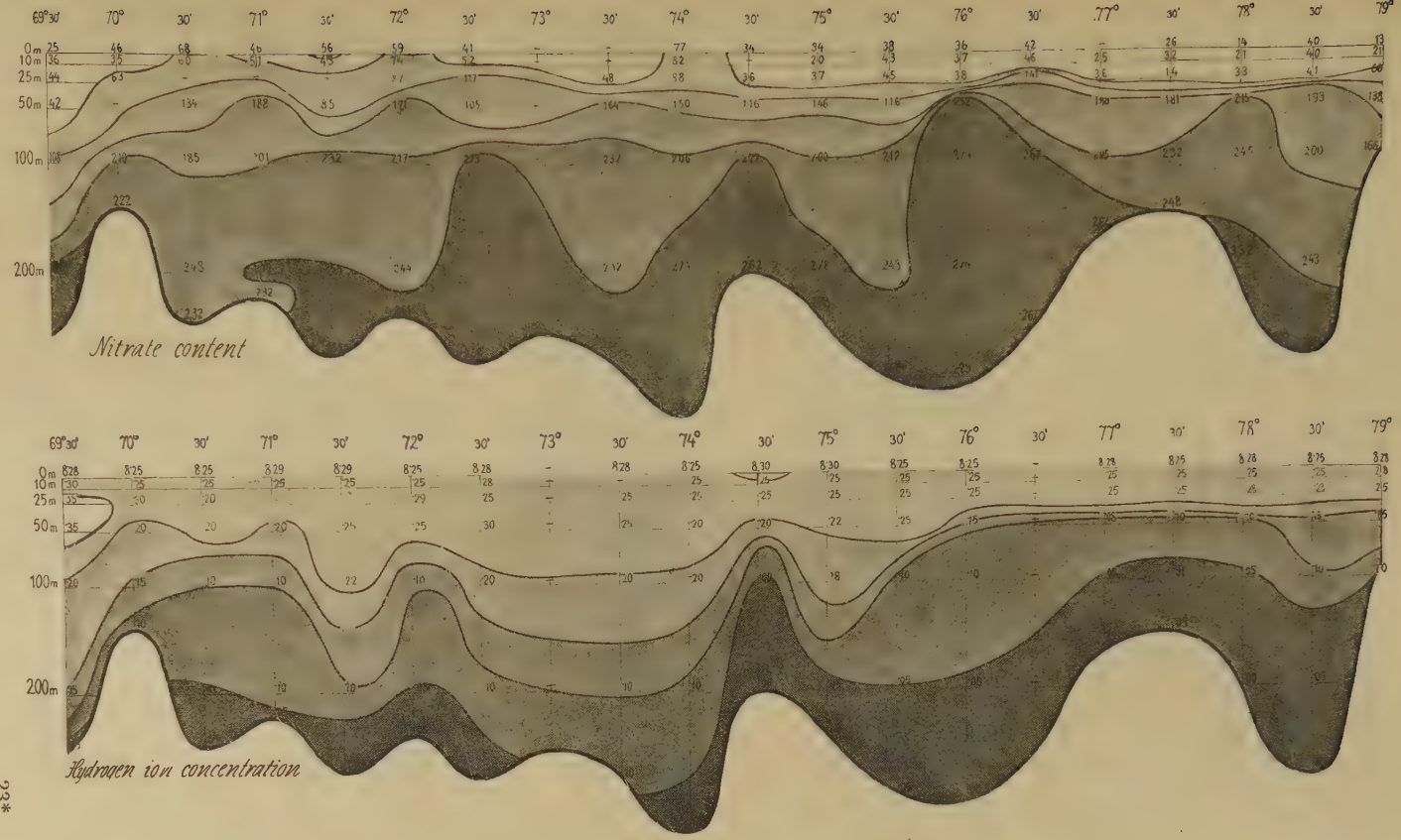


Fig. 3. Temperature, phosphate and nitrate content and hydrogen ion concentration along the Kola-meridian long. 33°30′ E. September 15—28 1929.

Atlantic, do not contain those species which are distinguished by an intense outburst of growth in the early spring. Perhaps the amount of light available in May is sufficient for the beginning of the development of algal spores of the arctic species, and not sufficient for the plankton algae of the Atlantic waters. A different intensity of vertical mixing in the Arctic and in the Atlantic waters may possibly also be of importance in the earlier outburst of plankton growth in the Arctic waters. More detailed observations are now being made and experiments are planned in order to elucidatc this question.

The great store of nutrient salts in the deep water is little by little

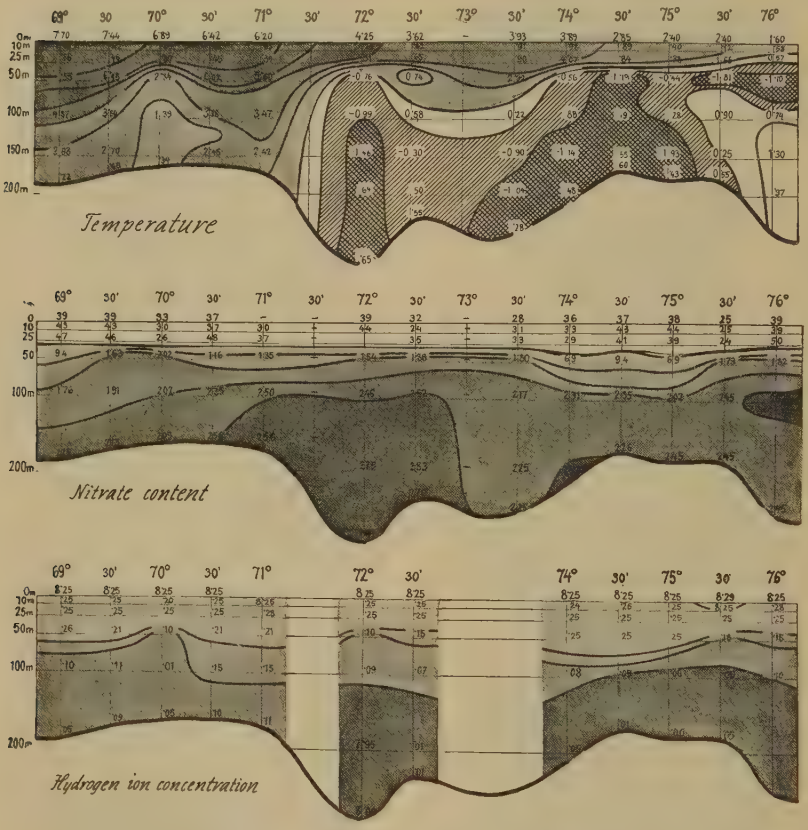


Fig. 4. Temperature, nitrate content and hydrogen ion concentration along the meridian long. 38° E. September 24—28 1929.

brought up by vertical mixing. Of course, the vertical mixing takes place more readily in winter, but the upwelling of deep water, rich in phosphates and nitrates, takes place also in the summer months. The

diagrams of P_2O_5, nitrate-N_2 and pH show us that nearly everywhere above banks and submarine plateaux the iso-lines of phosphates and nitrates rise up, indicating incursions of water rising from the deep strata of the sea. In these places the nutrient salts are carried up to the upper strata within the range of illumination. It is clear that in these regions a more abundant vegetation can flourish without exhausting the supply at hand, and a more numerous animal population may be fed, as compared with deep water. This statement is fully confirmed by zoological and fishery researches along the meridians.

Let us start now with the distribution of phosphates and nitrates in September (see diagrams Figs. 3 and 4). During the summer months the ice was driven to the north and in September it was possible to make the sections as far as lat. 79° N. along the Kola meridian and lat. 76° N. along the meridian 38° E.

The general picture of the distribution of the nutrient salts has changed. Now we can detect no difference between the Atlantic water of the North Cape current and the cold Arctic water. Everywhere the upper layers show a depletion of phosphates and nitrates, and everywhere the deep water is now rich in nutrient salts.

In accordance with such a vertical distribution of phosphates and nitrates, the H-ion concentration of the water along both the meridians shows a decrease in the upper strata and an increased acidity in deep water.

The plankton was collected, as before, and the chlorophyll content determined, as in the May samples. The relative quantities of chlorophyll in the plankton from the upper 25 metres are given in Table 2.

Table 2. The distribution of temperature and of chlorophyll in the upper 25 metres along the Kola meridian September, 1929.

sition	69°30′	70°	70°30′	71°	71°30′	72°	72°30′	73°	73°30′	74°
perature	8°06	7°93	7°94	7°14	7°75	6°81	6°57	5°81	6°66	5°95
rophyll	0	2.3×10^{-2}	traces	0	2.3×10^{-2}	2.7×10^{-2}	4.1×10^{-2}	0	0	0
ber cu.m.										
sition	74°30′	75°	75°30′	76°	76°30′	77°	77°30′	78°	78°30′	79°
perature	3°80	3°88	4°52	3°60	0°61	0°51	0°50	0°84	−1°0	−1°25
rophyll	0	0	traces	0	0	0	0	0	0	10×10^{-2}
ber cu.m.										

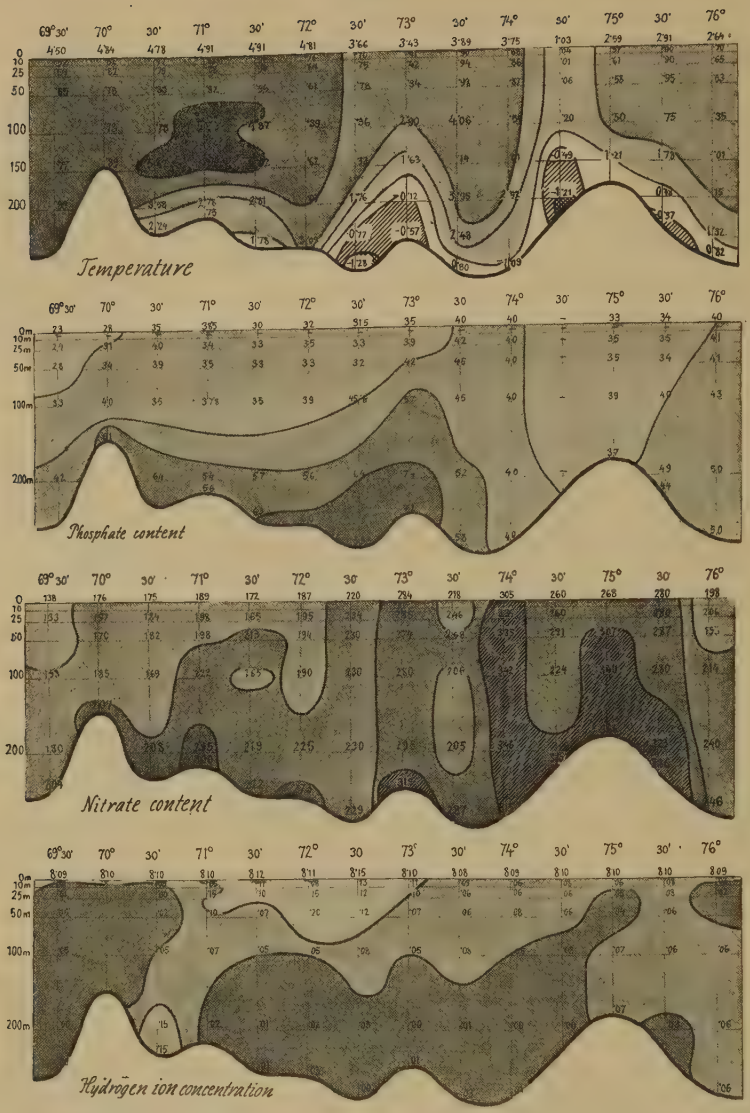


Fig. 5. Temperature, phosphate and nitrate content and hydrogen ion concentration along the Kola-meridian, long. 33°30′ E. December 22—29 1929.

These data compared with the distribution of temperature (Figs. 3 and 4) show us that in September the growth of phytoplankton took place principally in the regions of the warm Atlantic water, and not in the branches of the cold water. Thus the distribution of the plankton flora in September was quite the reverse of that in May. The possible cause of it may be the depletion of nutrient salts in the Arctic water, where the development and growth of algae had already begun

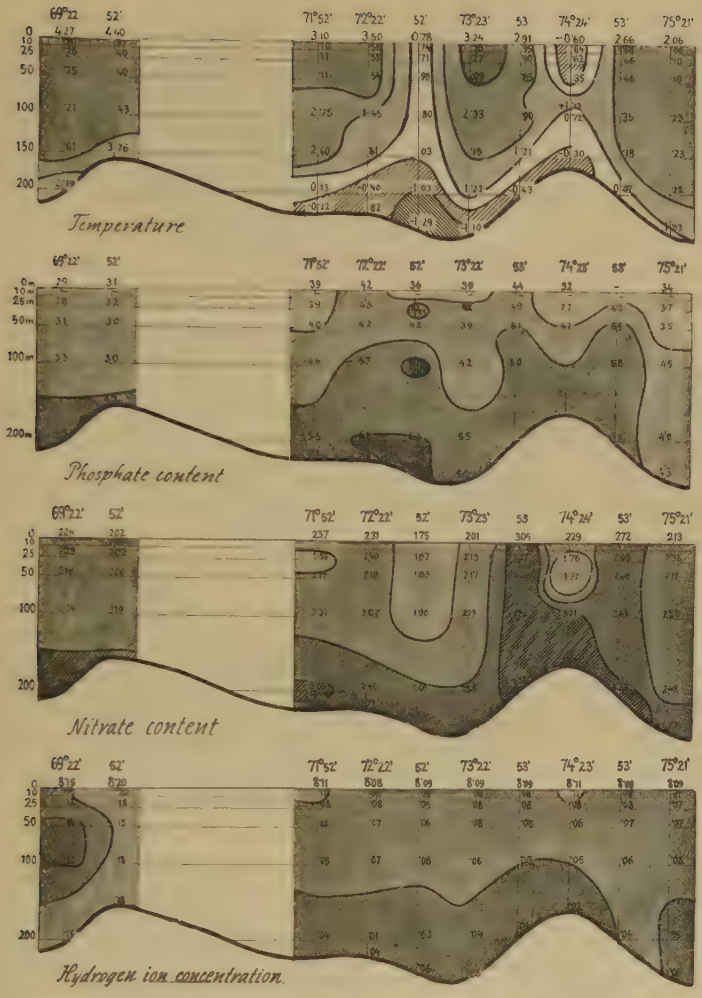


Fig. 6. Temperature, phosphate and nitrate content and hydrogen ion concentration along the meridian 38° E. December 31—Januar 5 1930.

in the early spring, whereas in the regions of the warm Atlantic water the vernal onset of phytoplankton growth started much later.

The above-mentioned influence of the bottom relief upon the physical and chemical conditions in the sea is also clearly seen in the September diagrams of temperature, pH, phosphates and nitrates. The diagrams show in many places an upwelling of water above submarine plateaux. A good illustration is given by the station lat. 74°30′ N., long. 33°30′ E. situated on a high plateau, where the depth did not exceed 200 metres. Cold, deep waters rich in phosphates and nitrates rise here, almost coming

within the range of the sun's illumination. To the north and to the south of this plateau the 3rd and 4th branches of the North Cape current flowed along channels in the bottom.

The winter conditions in the Barents Sea are shown in the diagrams of December cruises. The cruises in December 1929 reached as far as lat. 76° N. along the Kola meridian, and lat. 75°30′ N. along long. 38° E. (see Figs. 5 and 6).

When working on the 38° meridian the expedition was forced, because of rough weather, to leave out three stations (lat. 70°, 70°30′, and 71°). Unfortunately, the stations missed corresponded to the region where the stream of Atlantic water crossed the 38° meridian.

The data of the winter sections show us that 1) the utilisation of phosphates and nitrates in the upper layers has entirely ceased, and 2) the intense winter vertical mixing has set in. The end of December is the midst of the polar night; complete darkness reigns in high latitudes, and, of course, no photosynthetic activity could be carried on. Indeed, no green algae, no phytoplankton in general, could be detected in the plankton samples.

On the other hand, the vertical mixing takes place more readily now, because of the cooling of the surface water which gives rise to convection currents. Owing to the relative shallowness of the waters of the Barents Sea, and to a nearly uniform salinity, the vertical mixing involves all the strata from bottom to surface. As a matter of fact, the Barents Sea is one of the best mixed and aerated seas, and the saturation of dissolved oxygen, even in the bottom water, never sinks below 90 %.

The intense vertical mixing during the winter months brought about a nearly complete break-down of the layering, which was so markedly expressed in September. The content of phosphates and nitrates in the upper layers became greater than it had been in September, the hydrogen ion concentration also became higher.

Some difference may be discovered between the northern stations of the December section (Kola meridian) and the southern ones. The southern stations (from the shore as far as lat. 73° N.) still show some remnants of the layering in the content of nutrient salts. The upper strata are not yet so rich in phosphates and nitrates as the deep ones. Whereas on the northern stations (lat. 73°—76°) a complete mixing of all the strata has already taken place, and no difference could be observed between the surface layers and the deep ones.

The northern parts of the sea were thus the first to show the typical winter state of the sea, which is characterised by uniform chemical con-

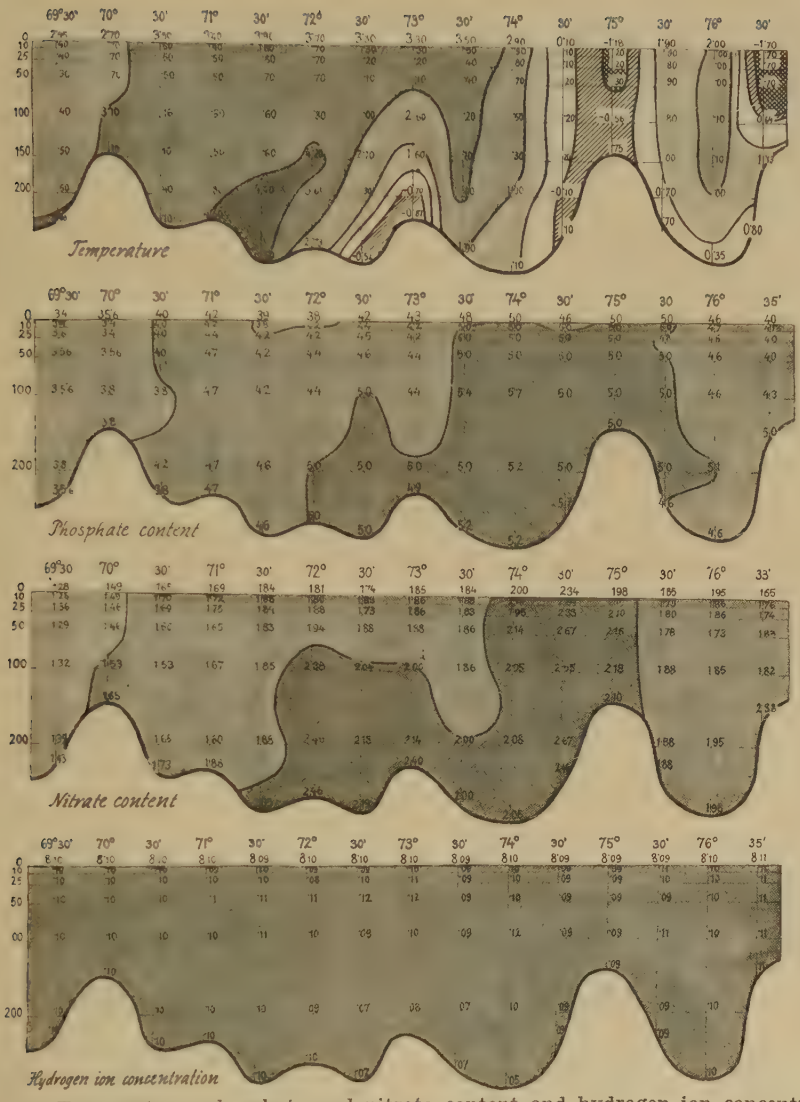


Fig. 7. Temperature, phosphate and nitrate content and hydrogen ion concentration along the Kola-meridian, long. 33°30′ E. March 28—April 6 1930.

ditions throughout its depth. The same thing had been observed in May, when the northern parts of the sea had been also the first to show the signs of the coming spring, – the outburst of plankton and the depletion of nutrient salts in the upper layers.

The next cruises were made at the end of March, and at the beginning

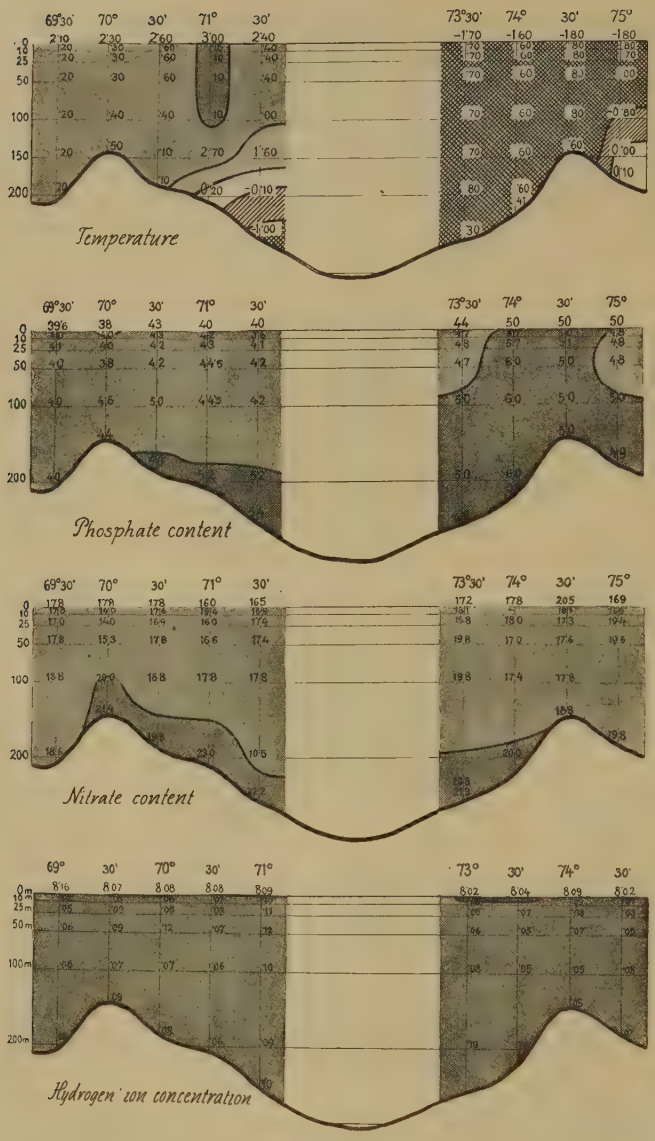


Fig. 8. Temperature, phosphate and nitrate content and hydrogen ion concentration along the meridian 36° E. April 8—11 1930.

of April. (A cruise along the Kola meridian alone was also made in February but, as it gave no new information supplementing that of the March cruises, we shall leave it out of consideration). The March sections reached as far as lat. 76°35′ N. along the Kola meridian and lat. 75° N. along the meridian 38° E. (see Figs. 7 and 8).

The conditions in the Barents Sea had never previously been investigated during this period (end of March—beginning of April) by the Murman Biological Station. We had no information about the dates at which phosphates and nitrates begin to be used up in the higher latitudes of the Barents Sea.

The cruises were made from March 28th to April 11th. They showed that no signs of the onset of vernal conditions in the sea could be detected at this period. No phytoplankton was discovered, the plankton nets catching only a little zooplankton (copepods).

The chemical conditions were quite typical of the end of winter. A fairly complete vertical mixing of the surface with the bottom water had taken place. The diagrams give a complete illustration of these conditions. Unfortunately, in the section along the meridian 38° E. three stations (lat. 72°, 72°30′ and 73°) were left out, because of stormy weather[1]).

On each station the content of nutrient salts was quite the same from bottom to surface. The hydrogen ion concentration also did not vary from top to bottom, nor from south to north.

But the content of phosphates and nitrates, though not changing with depth, was not the same at different positions. The diagrams show clearly that the Barents Sea, along the Kola meridian, may be divided into three parts, according to their relative richness in nutrient salts: 1) the inshore region, nearly 50 miles wide, where the phosphate content was below 40 mg. P_2O_5 per cubic metre, and the nitrate nitrogen was below 150 mg. per cubic metre, 2) the region between lat. 70°30′ N. and lat. 73° N. with a phosphate content of 44—47 mg. P_2O_5 per cubic metre, and nitrate content of 150—200 mg. nitrate-N_2 per cu. metre, and 3) the northernmost region (from lat. 73°30′ N. to lat. 75°30′), with a P_2O_5 content above 50 mg. per cu. metre and nitrate-N_2 content above 200 mg. per cu. metre.

The temperature diagram shows us that the regions of the sea, which differ from one another as to their phosphate and nitrate content, also differ as to their temperature. The inshore region had a mean temperature between 2° and 3°, and almost isothermal conditions from top to bottom.

The second region was the region of the Atlantic water, with a tempe-

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[1]) The eastern section (April 8—11) has been carried through in rather heavy conditions. Rough weather and the impossibility of taking bearings led to a deviation from a meridional direction; the section, begun in lat. 75° N. long. 38°E. was ended in lat. 69°N. long. 36°E., off the Gavrilova lighthouse.

rature above 3°. In the deep strata of its central part (lat. 71°—72° N.) we may find temperatures above 4° C. A wedge of cold Arctic water with negative temperatures penetrated into this region as a bottom current. The latter is apparent in the vertical section along the Kola meridian, at the positions lat. 72°30′ and 73° N. This wedge of cold Arctic water separated the main masses of Atlantic water — the 1st and 2nd branches of the North Cape current from the 3rd branch.

Farther to the north began the region of cold water, the most Arctic conditions having been found at position lat. 75°. This region was distinguished by a P_2O_5 content above 50 mg. per cu. metre and a nitrate-N_2 content above 200 mg. per cu. metre.

The temperature diagram of the vertical section along the meridian 38° E. shows us that the two masses of cold water, which had been separated from one another on the Kola meridian by the 3rd branch of the Atlantic current, were found further eastwards to be united as a continuous mass of water of negative temperature, occupying all the northern part of the section along long. 38° E. The temperature, phosphate and nitrate diagrams show a great resemblance. The band of warm Atlantic water, reappearing at lat. 76° N. (Kola meridian) — the 4th or Franz-Joseph branch — brought about a new decrease in the content of nutrient salts. The cooling of the surface water apparent at lat. 76°30′ N. is due to the melting of the ice. The station lat. 76°30′ was made when lying-to amid the floating ice.

Thus a comparison of the temperature of the water with the chemical data shows us that the waters of different origin also differ as to their relative richness in nutrient salts. The inshore waters are the poorest, and the water of the Atlantic stream is not so rich in nutrient salts as the colder water of the Arctic region. This is shown by the phosphate and nitrate content of the water when the winter conditions have set in and a complete vertical mixing of all the layers has taken place. The same feature can be found when the yearly means have been calculated from the data of the seasonal sections.

Summary.

1) In September and in March the distribution of nutrient salts and pH in the central part of the Barents Sea has certain typical features. In September a diminution of phosphates and nitrates in the upper strata, and an accumulation of them in deep water, are exhibited everywhere along the meridians 33°30′ and 38° E. The vertical layering

attains its highest degree. The water in the upper strata becomes more alkaline, in the depth more acid.

2) In March the conditions are quite opposite. No vertical layering can be detected. A mixing of all the layers has taken place. The phosphates, nitrates and hydrogen ion concentration show a uniform distribution from top to bottom.

3) In May and in December conditions are more or less transitional. In May the regions of Atlantic water still show the winter conditions, with no vertical layering, whereas the inshore waters and the Arctic waters already show a depletion of nutrient salts and a rise in H-ion concentration in the upper 25 metres, both arising from an outburst of phytoplankton. The bottom waters become richer in nutrient salts, owing to the decay of dead animals and plants.

4) In December the northern parts of the sea already show a complete mixing of the water due to strong convection currents, whereas the water coming from the Atlantic still keeps some trace of vertical layering. Thus, the northern part of the sea is always in advance in regard to the seasonal changes in nutrient salts.

5) The vernal and summer changes in phosphate and nitrate contents and H-ion concentration are caused by the planktonic algae and they are therefore proportional to the relative content in chlorophyll in the plankton samples. The re-establishment of a uniform vertical distribution is caused by the intense vertical mixing of the water in winter.

6) The Arctic water is somewhat richer in nutrient salts than the Atlantic water. The inshore waters, again, are poorer in them than the Atlantic water.

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Nitrates and Phosphates in the Southern Seas.

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From Sept. 7th, 1929, to April 7th, 1930, I accompanied Professor Hjort as his assistant on board the floating factory S.S. "Vikingen", on a voyage to the whaling grounds along the edge of the ice in the Weddell Sea. Our plan was, first, to make ourselves acquainted with the conditions in general; and second, to carry on certain researches, so far as this could be done on board the floating factory or its whaling boats. Thanks to the courtesy shown to us throughout, we were able to accomplish if anything rather more than we had anticipated.

Our idea was to work a complete hydrographic and biological station regularly once a week, if possible, from the floating factory; and also at other times as opportunity offered from one or other of the whaling boats. The work at each station included vertical hauls with various kinds of nets at different depths, and hydrographic observations with Nansen water bottles at depths of 1, 10. 25, 40, 75, 150, 250, 350 and 450 metres, and sometimes intermediate depths as well. The temperature was determined and samples taken at each depth for the determination of salinity, the quantity of oxygen, of P_H when the light conditions were favourable, and of dissolved nitrate, phosphate and (at certain depths) ammonia. It would have been helpful to have extended our observations to greater depths than 450 m., as was done at St. 3, where samples were obtained from 650 and 900 m. Our instruments could not, however, be used below these depths; and one has to go right down to 1500 m. in the Weddell Sea to find any appreciable change in the temperature — i. e. water below zero (Georg Wüst: Der Ursprung der Atlantischen Tiefenwässer. Berlin 1928). We decided, therefore, that apart from the practical difficulties there was no point in going deeper than 450 m. On

board the floating factory a large cabin measuring 2.5 × 4.5 m. was placed at our disposal; and this was fitted up as a laboratory during the voyage out. All the analyses were performed in this laboratory, with the exception of the ammonia analyses, which were made by Mr. Alf Klem at the University, in the Biological Laboratory, after our return.

Method.

In determining the quantity of dissolved phosphates we have used the method devised by Atkins, as described in Rapports et Procès-Verbaux Vol. LIII 1929 p. 96 f. The ready-made reagents required both for this purpose and for the ammonia analyses were prepared by Mr. Klem. They invariably proved very satisfactory; though it was necessary to add 4 instead of the usual 2 drops of $SnCl_2$ to get the right intensity of blue for the higher phosphate values.

On the voyage to the whaling grounds we took a number of surface samples to test our method, and found that the surface water in the lower latitudes contained no phosphate, or at any rate so little that we could not detect it by this method. We took the opportunity, therefore, to make a colorimetric phosphate scale, by comparing the colour bottles with surface water to which known quantities of phosphate and reagent had been added. We used photographic colours — blue, green and a little violet dissolved in water — and adjusted the scale to the values 45, 65, 105, 125, 145, 185, and 225 mg. per cubic metre. As compared with this sea-water our ordinary distilled water contained 20 mg. phosphate. This distilled water with additions was afterwards used to check the scale, the assumption being that it was only subject to negligible changes in the course of the season. The actual analysis was made in the colorimeter devised by Mr. Klem and described in a paper by Braarud and Klem (in the press). In the Weddell Sea the quantities of phosphate were always so large that there was no need to add anything in order to bring the analysis up to a proper intensity of colour.

Dissolved nitrates were determined by Harvey's method as described in Rapports et Procès-Verbaux Vol. LIII 1929 p. 100 f. A colorimetric nitrate scale had been made and adjusted at home. In using this scale on the voyage out, however, it was found that the colours had faded somewhat, probably on account of the high temperature and strong light in the tropics. Accordingly a new scale was made on Oct. 28th, and this was used thenceforward, the colours being constantly checked by distilled water containing known quantities of nitrate. For this new scale equal quantities of the photographic colours scarlet and crimson were used, and the units of colour were 2, 8, 16, 26, 40, 54, 70, 85, 100, 120, 140, 160, 200, 240, 280, 320 and 360.

In the Weddell Sea we found such large quantities of nitrates at all depths that direct analysis was difficult; the colours became too intense, and the intensities were not in linear relation in the case of high values. The samples had therefore to be diluted with distilled water, a 50/50 dilution proving sufficient. Our ordinary distilled water contained 15 mg.

nitrates, which had to be taken into account in the calculations. Such dilution involves, of course, various manipulations which might admit many sources of error, but the analyses afforded, as a rule, results which agreed so well that we may reasonably conclude that the errors, if any, were of minor importance.

With a 50/50 dilution the results of the analyses were usually between 170 and 250 units of colour. That the colour intensities of the reaction were rectilinear between these values could be seen from the checks, one of which, dated Dec. 4th, is given here:

Table 1.

	Mg. nitrate	Units of colour
Distilled water, specific value 15 mg. nitrate with additions to:	163	115
	212	155
	261	195
	310	235
	360	270

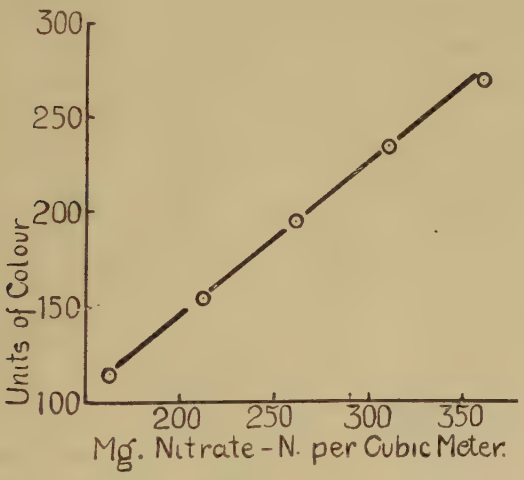

Fig. 1.

Every time we began using a new bottle of reagent we made double analyses with the old and new reagents in order to see whether they produced different reactions, and if so, to discover wherein the difference consisted.

The colour reaction of sea-water and distilled water differs slightly when the nitrate content is the same; it was therefore necessary to ascertain which colours corresponded to the nitrate values in sea-water. This was done with surface water taken from the sea near the equator. The water in question contained 14 mg. nitrate as compared with the distilled

water, and of this sea-water a series was made with various quantities of nitrate added. The zero nitrate value of the reagent is thus determined by means of distilled water instead of sea-water. The slight amount of error this entailed was negligible in comparison with the high nitrate values found in the Weddell Sea.

Samples of water for the ammonia analyses were only taken at certain depths at each station. We used the colorimetric method, with NESSLER's reagent as described by BUCH (KURT BUCH: Über die Bestimmungen von Stickstoffverbindungen und Phosphaten im Meerwasser. Rapports et Procès-Verbaux Vol. LIII 1929). The samples were stored on board and analyzed after our return, which means that the first samples were only analyzed after a lapse of five months.

Results.

When we had got our little laboratory in order we began to test our method by taking some samples of surface water — one a day from the equator to South Georgia and two a day from S. Georgia to the whaling grounds. The results are so interesting that I give them here in the subjoined table.

Table 2.

Date	Hour	Lat. S.	Long. W.	T.	S.	N.	P.	
$^{4}/_{10}$	11	0°37′	33°50′	..	..	23	..	From the equator to S. Georgia.
$^{5}/_{10}$	11	4°23′	32°47′	..	..	20	..	
$^{6}/_{10}$	13	8°44′	33°04′	..	36.00	23	0	
$^{7}/_{10}$	11	12°37′	33°16′	..	36,45	14	0	
$^{8}/_{10}$	10	16°55′	33°30′	..	37.09	20	0	
$^{9}/_{10}$	10^{30}	21°35′	33°45′	..	36.82	17	0	
$^{10}/_{10}$	9	25°54′	34°09′	..	36.33	20	0	
$^{11}/_{10}$	10	30°55′	34°30′	18°90	35.48	52	30	
$^{12}/_{10}$	9	34°45′	34°30′	15°59	35.43	26?	30	
$^{13}/_{10}$	9	38°33′	34°41′	12°32	34.97	110	40	
$^{14}/_{10}$	9	42°05′	34°50′	10°02	34.60	208	75	
$^{15}/_{10}$	8^{30}	46°30′	35°15′	7°30	34.52	260	95	
$^{16}/_{10}$	9	50°56′	35°56′	2°11	33.84	over 260	95	
$^{19}/_{10}$	16	54°09′	36°33′	1°50	33.40	—	155	Thence to the whaling grounds.
$^{20}/_{10}$	10^{30}	54°15′	34°30′	0°10	33.82	—	130	
$^{20}/_{10}$	16^{45}	54°32′	32°53′	÷0°70	33.82	—	145	
$^{21}/_{10}$	8^{30}	55°10′	28°07′	÷1°07	..	—	150	
$^{21}/_{10}$	16	55°08′	25°45′	÷0°60	33.57	510	145	
$^{22}/_{10}$	8^{30}	55°27′	23°40′	÷1°19	..	454	155	
$^{22}/_{10}$	16	55°40′	21°00′	÷1°16	33.60	416	155	
$^{23}/_{10}$	12	55°32′	20°24′	÷0°63	33.58	400	150	

It will be seen that between the equator and 25°54′ S. there are high salinities — more than 36 $^{0}/_{00}$ — and small quantities of dissolved

nutrient salts, the nitrates amounting to about 20 mg. and the phosphates to practically 0 mg. After 30°55′ S. there is a steady decrease in salinity and temperature all the way to the ice, while the quantities of nitrates and phosphates increase very rapidly. From Oct. 16th—21st

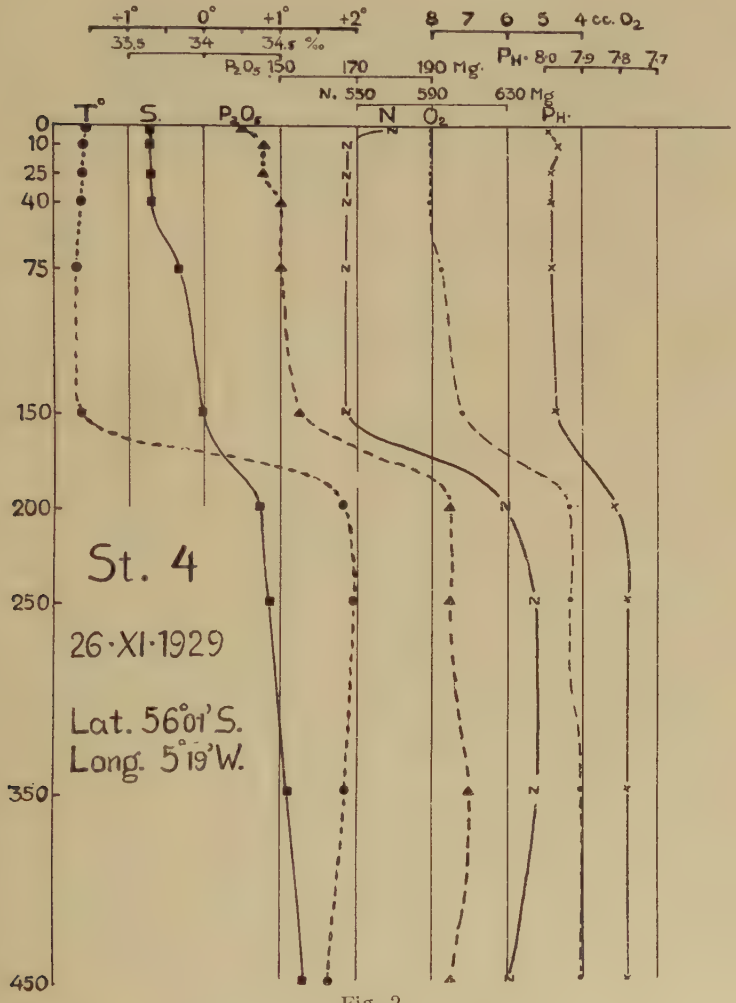

Fig. 2.

the nitrates could not be recorded more accurately than "over 260 mg.", as the scale was not made or adjusted for higher values.

Our first complete station was worked on Oct. 27th, after which date we tried to work a station every week so far as the conditions permitted. The results of all the analyses will be seen in the table 3 on p. 357.

It will be observed that the stations, 14 in all, can be divided into 3 types: type 1 including St. 1—5, type 2 St. 6—8, and type 3 St. 9—14. The stations of type 2 exhibit, on the whole, a gradual transition to type 3.

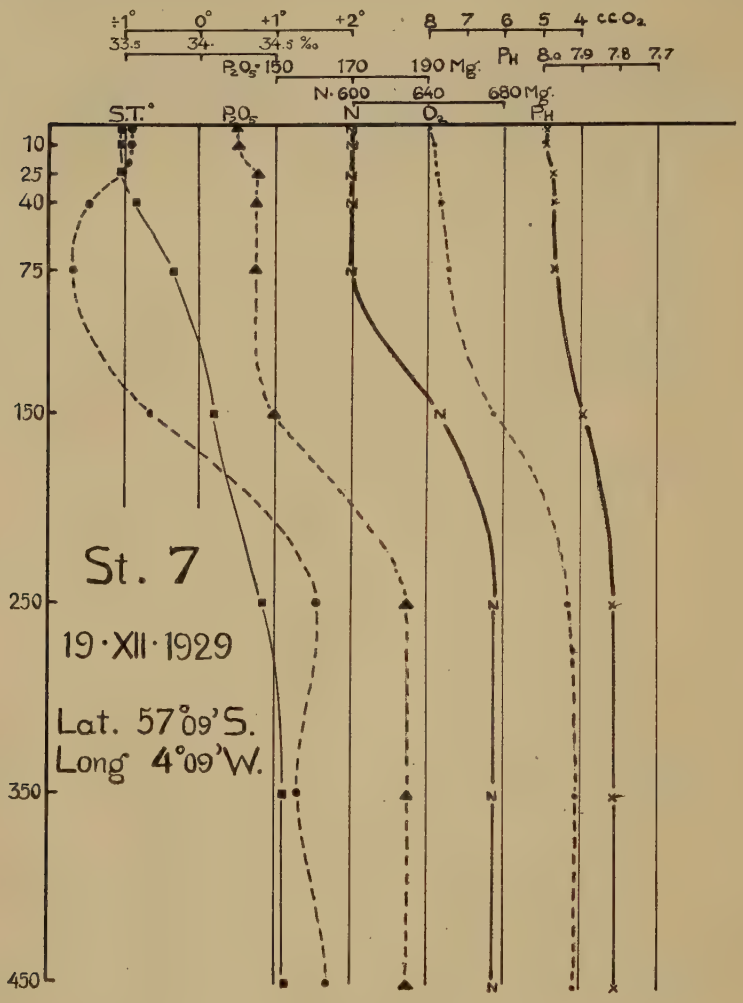

Fig. 3.

We may study these types a little more closely by taking a characteristic station of each type, namely St. 4, 7 and 13.

At St. 4, Fig. 2, there are two clearly defined layers of water, the upper having negative temperatures with a salinity under 34 $^0/_{00}$, and the lower positive temperatures with a salinity over 34 $^0/_{00}$. There is a clearly marked "sprungschicht" between 150 and 200 m. This is notice-

able also in the quantities of n.trate, phosphate and oxygen. The amount of phosphate increases from 155 to 195 mg., and the amount of nitrate from 545 to 630 mg. in this "sprungschicht". The oxygen decreases from

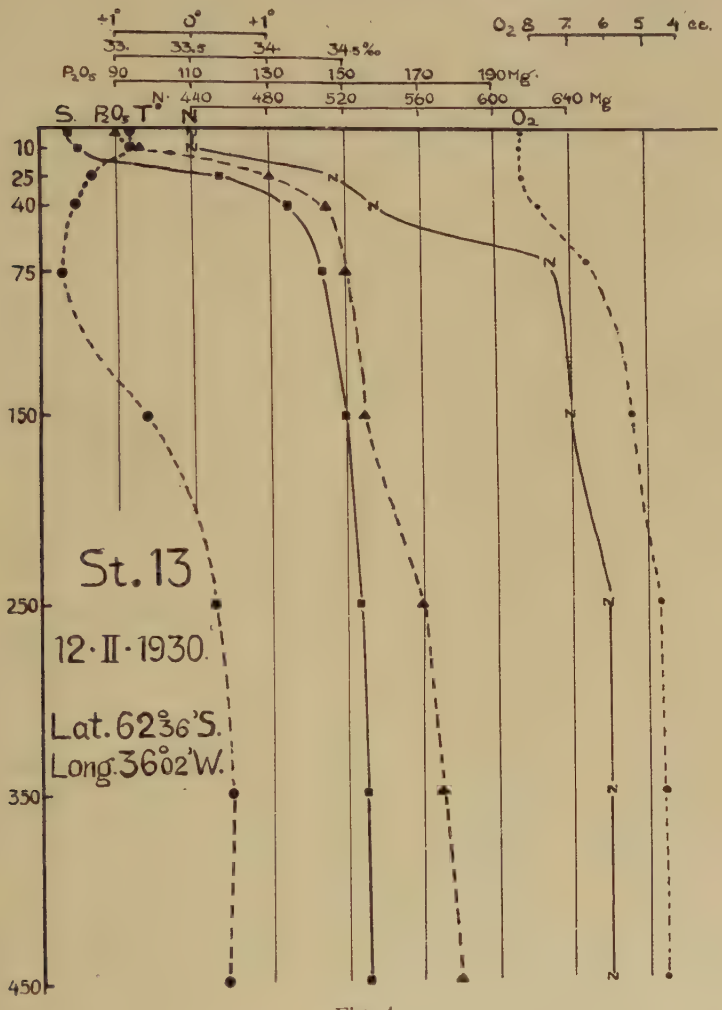

Fig. 4.

7.20 cc to 4.36 cc, and the percentage saturation from 85 to 56 % in the same stratum.

At St. 7 the curve of temperature (see Fig. 3) is decidedly different, assuming the form that is found at stations of the third type. From 0 to 25 m. the temperature is over — 1°. From 25 to 75 m. the temperature falls to — 1°62, after which it rises slowly without any marked

"sprungschicht". 0° occurs at about 175 m. The curve of salinity is more like that at St. 4, except that the salinity in the upper 25 m. is somewhat less, being under 33.50 ‰. From 25 m. downward it increases more evenly with the increase in depth. At 120 m. we find 34 ‰. The other curves are also without the abrupt "sprungschicht" characteristic of St. 4.

At St. 13 (Fig. 4) we have the same curve of temperature as at St. 7, but the curve of salinity differs considerably. The salinity above 10 m.

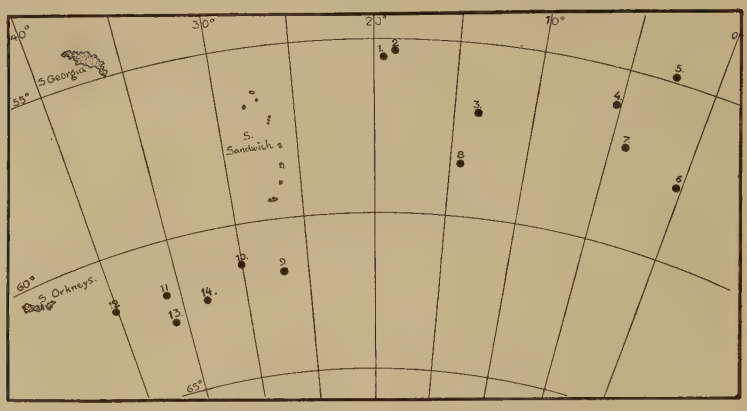

Fig. 5. S.S. »Vikingen«: Wedell Sea 1929—30.

is quite low — less than 32.75 ‰; but after that it increases rapidly down to 40 m., where it is 34.11 ‰. As we go farther down the salinity increases slowly. The phosphates and nitrates here follow the salinity very closely. From 10 to 40 m. the phosphates increase from 95 to 145 mg., and the nitrates from 440 to 540 mg. Thereafter the quantity of nitrates increases rapidly down to 75 m., where it amounts to 630 mg. From that depth onward the increase is trifling. The oxygen curve shows movements of a corresponding nature.

At none of these stations is ammonia present in unusual quantities. The amounts always correspond in order of magnitude with those found elsewhere in ocean water.

The positions of all the stations are marked on the map Fig. 5.

Discussion.

The three types of stations fall into two groups: in one group, lying to the north and east, are the stations of types 1 and 2; in the other, to the south and west, we have those of type 3. It is naturally difficult to say how far the difference between the three types is due to this differ-

ence in locality, or to a difference in the time of year. There are, however, certain interesting features which will help us to understand the problem.

The map shows that stations 4 and 7 are comparatively near together; the distance between them is only about 80 nautical miles. The difference of time is from Nov. 26th to Dec. 19th. Further, we have already noted that, in spite of this, the curve of temperature for St. 7 is of the same type as the one for St. 13, and altogether different from the one for St. 4. So far as we can tell at present, the water transported in the upper layers of the Weddell Sea flows from SW. to NE. We may therefore assume that the state of things found in the south-west presents features which would probably be encountered at a somewhat later date in the north-eastern area. The low salinity in the upper 25 m. at the latter stations is, no doubt, also due mainly to the melting ice. Accordingly we may to some extent regard the difference between stations of types 1, 2 and 3 as an expression of changes occurring in the hydrographic situation during the season in these waters. On that assumption it will be interesting to examine the quantities of nutrient salts dissolved in the productive layers of water. We will look at the changes at a depth of 10 m. Here production of phytoplankton nearly always continues, notwithstanding much cloudy weather with a bad light and a certain amount of drifting ice. At this depth the decrease in the quantity of nitrates and phosphates from St. 4 to 13 is 160 mg. and 50 mg. respectively per cubic metre. There is also a reduction in the salinity, which decreases from 33.64 to 32.75 $^0/_{00}$. Presumably the last-mentioned decrease is due to an admixture of ice-water.

On the 5th Nov. we analyzed some melted ice and found that this water contained 70 mg. nitrate and 30 mg. phosphate, with a salinity of 3.73 $^0/_{00}$. Here we must infer that the melted ice was adulterated with surface water containing at the time 33.50 $^0/_{00}$ salt, 550 mg. nitrate and 150 mg. phosphate. This means that the adulteration of the ice-water with nitrates was equivalent to $\frac{3.73}{33.50} \cdot 550$ mg $= 60$ mg., and that the adulteration with phosphates was equivalent to $\frac{3.73}{33.50} \cdot 150 = 17$ mg.

According to this, pure ice-water should not contain more than about 10 mg. nitrates and 13 mg. phosphates per m^3. The sources of error in the conditions under which we obtained the ice for this analysis were certainly so great that we may put the nitrate and phosphate content of the ice at 0 mg., which agrees with our analysis of the ice in Denmark Strait (not yet published). Together with the decrease in salinity from

St. 4 to 13 there will thus be a decrease in nitrates and phosphates owing to dilution. This can be found by the equation below:

$$600 - \frac{32.75 \cdot 600}{33.64} = 600 - 584 = 16 \text{ mg. nitrates and}$$

$$145 - \frac{32.75 \cdot 145}{33.64} = 145 - 141 = 4 \text{ mg. phosphates.}$$

From this we see that the dilution is responsible for a decrease of 16 mg. nitrates and 4 mg. phosphates. But there is still a decrease owing to production, amounting to 144 mg. nitrate and 46 mg. phosphate. This indicates a much larger consumption than is usual in Norwegian coastal waters; but of course we never find such enormous quantities of phytoplankton there as we do in the Weddell Sea.

With such a huge production we might perhaps expect large supersaturations of oxygen, but the most that we find is 105 % at St. 9, 101.9 % at St. 11, and 101.1 % at St. 12. The maximum at St. 13 is 99.6 %.

To return to our comparison of stations 4 and 13, the increase of oxygen is not more than 0.32 cc per litre at 10 m. One possible explanation is that, on account of the low temperature, photosynthesis takes place more slowly than it does in spring in Norwegian waters; the surplus oxygen has therefore more time to get diffused. Another explanation might be that the quantity of zoo-plankton is so great that the breathing counterbalances the oxygen produced by the phytoplankton.

Down in the Weddell Sea all the problems with which we have been dealing for years in the waters off the coast of Norway confront us on a larger scale. In the Weddell Sea there are larger systems of currents and fewer disturbing factors than we are accustomed to find elsewhere. Not improbably, therefore, these antarctic waters afford the best conditions for solving some of the problems of oceanic production that we are studying to-day — *inter alia* the problems of the renewal of nutrient salts dissolved in the upper layers and of the part played by light in the process of production itself.

Table 3.

M	T°	Cl.	S‰	NO_3-N	P_2O_5	NH_4-N	O_2	M%	P_H	σ_t
St. 1. $^{27}/_{10}$ 29. 14 h. 55°32′ S. 19°4′ W.										
1	—1.53	18.62	33.64	..	150	45	8.06	95.5	..	27.09
10	—1.53	.62	.64	545	150	..	.15	96.2	..	.09
25	—1.51	.64	.68	545	150	..	.20	97.2	..	.12
40	(—1.20)	.65	.69	..	150	43	.02	94.6	..	.13
75	—1.38	..	..	590	150	..	.01	95.2	..	..
150	—0.35	.79	.95	590	160	10	6.58	80.3	..	.29
250	+1.70	..	..	600	190	33	4.31	55.8	..	..
350	+1.81	19.14	34.58	610	195	..	4.12	53.4	..	.67
450	+1.70	.16	.61	610	190	35	4.21	54.3	..	.71
St. 2. $^{3}/_{11}$ 29. 10 h. 55°24′ S. 18°29′ W.										
1	—0.70	18.57	33.55	515	150	..	8.06	97.0	..	26.99
10	—0.71	.61	.62	530	150	..	.13	98.5	..	27.05
25	..	.64	.68	530	150	..	7.90	95.5	..	.09
40	—0.95	.65	.69	545	150	0	8.04	96.5	..	.10
75	—1.08	.69	.77	560	150	..	.20	98.2	..	.17
200	+1.37	19.01	34.33	660	190	27	4.72	60.4	..	.49
300	+1.85	.10	.51	695	200	..	4.10	53.2	..	.61
450	+1.94	.15	.60	710	195	23	4.05	52.8	..	.67
St. 3. $^{13}/_{11}$ 29. 11—15 h. 56°50′ S. 13°09′ W.										
1	—1.53	18.64	33.68	634	155	..	7.80	92.5	8.01	27.12
10	—1.54	.66	.71	520	150	..	.80	.5	7.93	.15
25	—1.62	.66	.71	548	150	..	.80	.2	.93	.15
40	—1.74	.66	.71	548	150	15	.84	.2	.93	.15
75	—1.75	.72	.82	576	150	..	.65	90.1	.95	.25
125	—1.20	.80	.96	604	150	40	6.84	82.0	.96	.34
200	+1.31	19.07	34.45	642	190	..	4.44	56.8	.76	.60
400	+1.65	.19	.67	642	190	..	4.23	54.8	.75	.76
625	+1.56	.25	.78	604	205	..	4.25	54.9	.77	.85
900	+1.27	.20	.69	604	195	15	4.45	56.9	.77	.79
St. 4. $^{26}/_{11}$ 29. 8^{30}—11 h. 56°01′ S. 5°19′ W.										
1	—1.54	18.62	33.64	570	140	..	8.00	94.5	7.99	27.09
10	—1.57	.62	.64	545	145	60	.03	.8	.96	.09
25	—1.59	.62	.64	545	145	..	.01	.6	.98	.09
40	—1.61	.62	.64	—	150	15	.07	95.0	.98	.09
75	—1.67	.72	.82	545	150	..	7.78	91.7	.98	.25
150	—1.62	.81	.98	545	155	..	.20	85.2	.97	.37
200	+1.80	19.02	34.36	630	195	..	4.36	56.4	.81	.49
250	+1.96	.06	.43	645	195	15	.35	.6	.78	.54
350	+1.85	.12	.54	645	200	..	.05	52.7	.78	.64
450	+1.62	.18	.65	630	195	12	.05	.5	.78	.74

Table 3 (continued).

M	T°	Cl.	S ‰	NO_3-N	P_2O_5	NH_4-N	O_2	M %	P_H	σ_t
St. 5. $^2/_{12}$ 29. 15^{30}—18^{30} h. 54°52′ S. 2°30′ W.										
1	—1.20	18.62	33.64	510	145	..	8.04	95.9	7.97	27.08
10	—1.22	.62	.64	520	145	..	.21	97.9	.96	.08
25	—1.27	.62	.64	545	145	..	.18	.1	.95	.08
40	—1.32	.62	.64	520	150	..	.25	.6	.94	.08
75	—1.32	.62	.64	520	150	..	.06	95.4	8.01?	.08
150	—0.70	.80	.96	545	160	..	6.60	80.0	7.94	.31
200	+0.97	.94	34.22	620	200	..	4.89	62.0	.81	.43
250	+1.61	19.04	.40	620	200	..	.50	58.0	.76	.54
350	+1.79	.09	.48	630	210	..	.13	53.5	.78	.59
450	+1.79	.12	.54	620	200	..	.12	.5	.78	.64
St. 6. $^{12}/_{12}$ 29. 10—12 h. 57°39′ S. 0°18′ W.										
1	—1.26	18.72	33.82	630?	..	..	8.19	97.7	8.06	27.23
10	—1.28	.73	.84	580	140	13	.21	98.0	.06	.24
25	—1.42	.73	.84	530	140	..	.27	.1	.06	.24
40	—1.55	.74	.86	580	140	0	.00	94.8	.05	.25
75	—1.38	.96	34.25	630	140	..	6.10	72.8	7.94	.57
150	—0.42	19.05	.42	630	145	..	5.67	69.4	.89	.67
250	+0.61	.12	.54	640	155	..	4.84	61.0	.86	.72
350	+0.82	.18	.65	680	160	..	.60	58.2	.86	.79
450	+0.68	.18	.65	680	160	12	.63	.3	.86	.80
St. 7. $^{19}/_{12}$ 29. 14—17 h. 57°09′ S. 4°09′ W.										
1	—0.95	18.52	33.46	600	140	..	7.99	95.9	7.99	26.92
10	—0.95	.52	.46	600	140	17	.86	94.1	.99	.92
25	—1.02	.52	.46	600	145	..	.78	93.2	.97	.92
40	—1.49	.59	.58	600	145	20	.67	90.8	.97	27.04
75	—1.62	.73	.84	600	145	..	.43	87.9	.97	.25
150	—0.55	.87	34.09	644	150	..	6.21	75.7	.89	.41
250	+1.53	19.07	.45	675	185	15	4.29	55.2	.81	.59
350	+1.29	.13	.56	675	185	..	.07	52.2	.81	.69
450	+1.67	.14	.58	675	185	0	.16	53.8	.81	.69
St. 8. $^{27}/_{12}$ 29. 9^{30}—17 h. 58°28′ S. 14°22′ W.										
1	—0.73	18.38	33.21	475	120	..	8.08	97.1	8.15	26.71
10	—0.75	.38	.21	485	130	60	.13	.6	.15	.71
25	—0.86	.39	.22	485	130	..	.07	96.9	.15	.73
40	—1.16	.41	.26	500	140	27	.00	95.3	.14	.76
75	—1.55	.68	.75	525	150	..	7.57	88.2	.12	27.17
150	+1.11	.96	34.25	600	185	..	4.94	62.7	7.92	.45
250	+1.86	19.14	.58	625	195	15	.11	53.4	.88	.67
350	+1.74	.18	.65	625	195	..	.27	55.2	.88	.73
450	+1.74	.18	.65	625	195	19	.27	.2	.88	.73

Table 3 (continued).

M	T°	Cl.	S ‰	NO_3-N	P_2O_5	NH_4-N	O_2	M %	P_H	σ_t
St. 9. $^6/_1$ 30. 10—13^{30} h. 61°44′ S. 26°48′ W.										
1	—0.95	18.59	33.58	420	125	..	8.38	105.0	8.10	27.03
10	—0.92	.59	.58	432	125	60	.21	98.5	.08	.03
25	—0.92	.62	.64	444	130	..	.36	103.0	.07	.06
40	—1.58	.88	34.11	546	150	15	7.41	87.8	.03	.47
75	—1.74	19.01	.34	570	150	..	6.72	79.4	.01	.66
150	—1.41	.07	.45	620	170	..	.09	72.7	7.97	.73
300	+0.27	.18	.65	644	190	23	4.39	54.9	.92	.82
450	+0.22	.19	.67	644	190	15	.55	56.7	.91	.85
St. 10. $^{14}/_1$ 30. 19—22 h. 61°19′ S. 29°58′ W.										
1	—0.89	18.57	33.55	390	140	..	..	..	..	27.00
10	—1.27	.58	.57	455	140	5	7.96	94.7	..	.02
25	—1.31	.64	.68	470	145	..	8.08	96.1	..	.11
40	—1.69	.94	34.22	480	150	20	7.36	87.1	..	.55
75	—1.75	19.00	.33	495	160	..	6.68	79.0	..	.64
150	—1.10	.08	.47	520	165	..	5.81	69.8	..	.74
250	+0.26	.16	.61	580	185	8	4.93	61.7	..	.84
350	+0.32	.17	.63	595	185	..	.47	56.1	..	.85
450	+0.32	.18	.65	595	185	17	.52	.6	..	.86
St. 11. $^{22}/_1$ 30. 19^{30}—22 h. 61°42′ S. 36°15′ W.										
1	—0.39	18.24	32.95	340	95	..	8.29	100.2	..	26.50
10	—0.49	.26	.99	340	95	15	.43	101.9	..	.53
25	—0.88	.47	33.37	420	105	..	.43	.0	..	.87
40	—1.12	.68	.75	450	135	25	7.94	94.7	..	27.16
75	—1.42	.96	34.25	560	155	..	6.51	77.5	..	.58
150	—1.07	19.08	.47	570	160	..	5.92	71.2	..	.74
250	—0.23	.14	.58	580	160	7	.33	65.8	..	.80
350	+0.02	.16	.61	595	175	..	.12	63.5	..	.82
450	+0.20	.18	.65	595	180	12	4.88	60.9	..	.83
St. 12. $^{28}/_1$ 30. 13, 18, 19—20^{30} h. $^{29}/_1$ 9^{30} h. 61°37′ S. 40°09′ W.										
1	—0.22	18.38	33.21	400	90	..	8.30	101.0	8.22	26.69
10	—0.18	.39	.22	390	100	7	.29	.1	.24	.71
25	+0.02	.55	.57	420	100	..	.22	.1	.24	.97
40	—0.72	.82	34.00	440	140	55	7.45	90.1	.20	27.35
75	—1.58	.94	.22	510	165	..	6.73	79.9	.10	.55
150	—1.03	19.06	.43	520	170	..	5.80	70.1	.08	.71
250	—0.42	.12	.54	596	180	5	.46	67.1	7.82	.78
350	—0.09	.13	.56	596	185	12	.11	63.4	.80	.78

Table 3 (continued).

M	T°	Cl.	S‰	NO_3-N	P_2O_5	NH_4-N	O_2	M%	P_H	σ_t
St. 13. $^{12}/_{2}$ 30. 16—18^{30} h. 62°36′ S. 36°02′ W.										
1	—0.82	18.09	32.68	440	90	..	8.30	99.2	8.15	26.29
10	—0.83	.13	.75	440	95	10	.32	.6	.16	.35
25	—1.32	.64	33.68	514	130	..	.28	98.4	.13	27.11
40	—1.52	.88	34.11	536	145	4	7.89	93.6	.12	.47
75	—1.71	19.01	.34	630	150	..	6.53	77.2	.08	.66
150	—0.60	.09	.49	640	155	..	5.39	72.5	7.98	.73
250	+0.25	.14	.58	660	170	..	4.65	58.1	.86	.77
350	+0.49	.17	.63	660	175	..	.54	57.0	.88	.80
450	+0.42	.17	.63	660	180	2	.51	56.7	.89	.80
St. 14. $^{17}/_{2}$ 30. 13^{30}, 19—21 h. 62°11′ S. 33°42′ W.										
1	—1.25	17.93	32.39	420	..	..	8.16	96.3	..	25.98
10	—1.25	.97	.47	430	90	5	.27	97.5	..	26.04
25	—1.41	.99	.50	440	100	..	.24	96.8	..	.05
40	—1.53	18.84	34.04	495	150	2	7.49	88.9	..	27.29
75	—1.72	.93	.20	608	150	..	6.76	79.9	..	.42
150	—1.02	19.07	.45	620	170	..	5.83	70.4	..	.62
250	+0.17	.16	.61	620	180	..	4.68	58.4	..	.81
350	+0.40	.17	.63	620	185	5	.61	57.4	..	.81

An Apparatus for Recording the Valve Movements and the Extrusion of Dejecta of Oysters.

By

H. Marshall Webb.

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Introductory.

During the course of experiments in oyster purification carried out at the Fisheries Experiment Station, Conway, it was considered that it might be of interest to undertake, in addition to the bacteriological work, which constituted the predominant part of the investigation, observations on the behaviour of oysters under the various conditions set up as a result of the experimental procedure adopted.

Direct observations of the only two outward manifestations of the activity of the oyster, namely the opening of the valves and the extrusion of dejecta is, at all events in the experience of the writer, a matter of considerable difficulty. In any case, and particularly when dealing with oysters with markedly imbricated shells, it is well-nigh impossible to ascertain by inspection whether the valves are closed or very slightly open. Furthermore, when a number of oysters are under observation in the same vessel, the scattering of the dejecta, on expulsion, by the flapping of the valves, precludes any decision being arrived at as to whether particular oysters have or have not passed faeces and/or pseudo-faeces[1]).

To overcome the first mentioned difficulty, that of ascertaining whether the oysters were closed or slightly open, the obvious expedient suggested itself of magnifying and recording the valve excursions on a revolving drum by means of a pen lever. An instrument was extemporized,

[1]) A term introduced by Dr. Dodgson to denote the solid material evacuated by mussels, oysters and other lamellibranchs, which has not passed through the alimentary canal, but which is ejected, in the case of the mussel, in the form of threads, by the ciliary recurrent marginal streams, and in the case of the oyster, in the form of pellets, also by ciliary action, aided however, by the flapping of the valves. For a full description of the pseudo-faeces of mussels, *vide* "Report on Mussel Purification" (Ministry of Agriculture and Fisheries. Fishery Investigations. Series II. Vol. X, No. 1, 1928) by R. W. Dodgson.

allowing of tracings of four oysters being obtained simultaneously on the same drum, and with it a number of records were obtained. This instrument, though of rough construction, was quite satisfactory as regarded performance, but in spite of the advantage attaching to it by virtue of its furnishing a continuous record, it suffered, as must all such-like auto-recording devices, unless of unwieldy proportions and unmanageable complexity, from the serious defect of providing the means for observing the valve excursions of only a relatively few oysters at a time.

The expedient which was adopted to obviate the scattering of the dejecta of oysters so that it might be determined whether particular oysters had or had not passed faeces and/or pseudo-faeces was of such simplicity that it was the easiest of operations to ascertain at the end of an experiment what proportion, and which, of (say) one hundred oysters under observation had passed faeces and pseudo-faeces respectively. The procedure consisted of setting out the desired number of oysters, selected as suitable as regarded shape (somewhat convexo-concave), convex side upwards, each in a Petri dish (without cover), filling the dishes with water to prevent their floating on the filling of the tank in which the experiment was conducted, and allowing them to remain undisturbed at the bottom of the tank for the duration of the experiment, at the termination of which, the tank was emptied, any dejecta which the oysters might have passed remaining, in water, in the dishes, faeces and pseudo-faeces being readily distinguishable by inspection. This procedure, of course furnished no information as to the onset, duration or termination of the period during which the oysters were passing dejecta; no other information, in fact, than a categorical answer to the question as to whether each oyster had passed faeces and/or pseudo-faeces at some time during the experiment.

The apparatus about to be described, to which the name of "Ostreagraph" has been given, was designed with the idea of embodying in one instrument means for recording autographically the valve movements of four oysters simultaneously, together with provision for obtaining a rough registration of the times of the extrusion of the dejecta of each oyster. It may be remarked in passing that the application of the method of autographic record — a commonplace of the physiological laboratory — to oysters is no new thing. NELSON[1]) and GALTSOFF[2]) both employed

[1]) THURLOW C. NELSON. Report of the Department of Biology of the New Jersey Agricultural College Experiment Station, New Brunswick, N.J. for the year ending June 30th 1920.

[2]) PAUL S. GALTSOFF. Experimental study of the function of the oyster gills and its bearing on the problems of oyster culture and sanitary control of the oyster industry. Bulletin of the Bureau of Fisheries. Vol. XLIV. 1928.

it for their respective purposes. The only interest, if any, attaching to the apparatus about to be described, *qua* apparatus, arises out of its dual function and out of the fact that it was constructed at no great cost, largely out of ready-made components.

For the construction of the instrument only the usual metal-working loose tools, including drills, stock and dies and taps up to $^3/_8$ inch are necessary. The machined components are purchasable at small cost and readily adapted. In view of the possible interest of the information to those who may wish to make instruments similar to that about to be described, the last section gives the names and addresses of the firms from which such components as are not easily obtainable locally may be purchased. Each of these components on its first mention in the section devoted to the details of construction is allotted a reference number by which the firm from which it is obtainable may be identified in the list set out in the last section. The writer need hardly add that he disclaims any connection with any of the firms mentioned in the list, which is merely appended as explained above, for the information of those who from time to time make incursions into the domain of instrument construction. If their experience tallies with that of the writer, they will not infrequently have been at a loss to know where to buy this component or that material, particularly in such small quantities as are usually required.

It cannot be said that the part played in the research on oyster purification by the apparatus which forms the subject of this article, or by its precursor, referred to above (the apparatus by which the valve movements of four oysters were recorded together on a common drum) has been a large one. In the first place such work, requires the expenditure upon it of no small amount of time, and during the seasons during which the large scale purification experiments were carried out (the winter months of the year), personal manipulation and/or supervision in connection with the preparations for and the carrying out of the large-scale experiments, together with the concomitant bacteriological analyses of samples of oysters collected at the various stages of treatment, has left little time available for subsidiary undertakings, whilst during the remainders of the years during which the investigation was in progress other pre-occupations have supervened. Secondly, the first sets of tracings obtained (with the original apparatus), of the valve movements of different oysters under identical conditions showed such lack of uniformity that the opinion was formed, rightly or wrongly, that there was little expectation that tracings typical of different sets of conditions would be forthcoming, and this particular branch of the research was made to

give way to what were conceived to be more important aspects of the investigations. Thirdly, the apparatus, a general description of which is given below, was not completed until the experiments in oyster

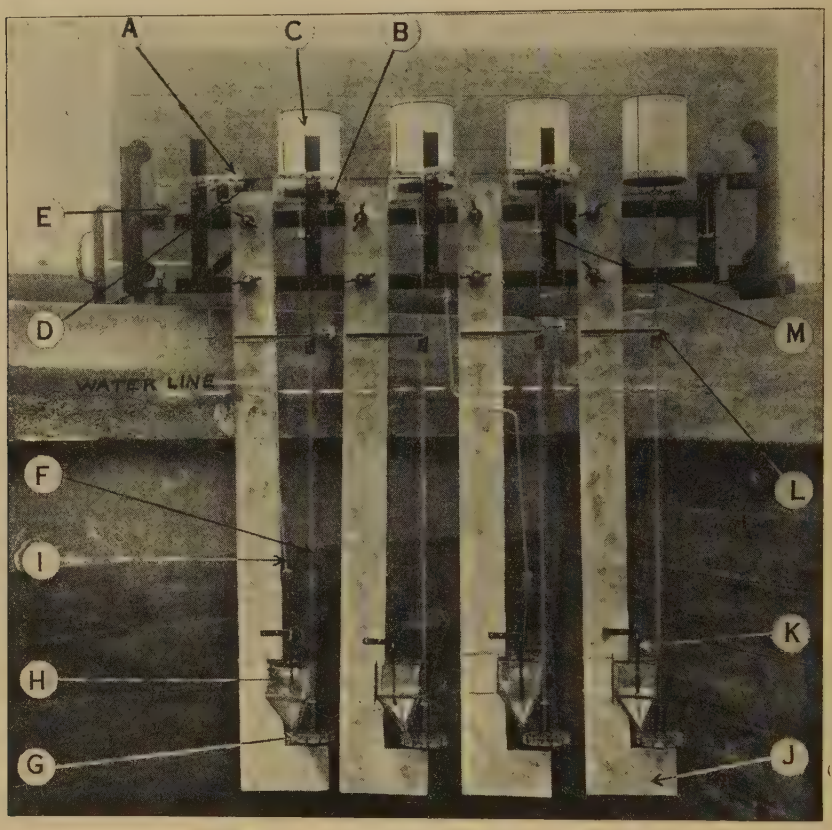


Fig. 1.

purification were nearing their conclusion. It is hoped, however, that an opportunity will offer itself for further work with the Ostreagraph in the future.

General Description of Apparatus.

A general idea of the design and working of the ostreagraph will now be given, reference being made to Fig. 1, in which attention may first be drawn to the "water-line", below which part of the instrument is submerged when in use. Allowance is made for some 18 inches of water over the four oysters under experiment, which are situated within the four celluloid hoppers *H*. Within each hopper an oyster is rigidly sup-

ported by means of a suitably bent iron rod *K*, one end of which is fixed to the lower valve of the oyster by means of Portland cement, the other end of the rod, flattened out, being bolted to the slate L-shaped member *J*. Thus each oyster is fixed under about 18 inches of water, partially enclosed by the celluloid hopper *H*, through the constricted opening at the bottom of which the dejecta fall, to be collected as will be explained later. To the upper valve of the oyster, which is free to make its normal movements, one end of a connecting rod *I* is attached by means of a simple ball-and-socket joint, the other end of the connecting rod actuating a counterpoised pen *D* which records on a rotating drum *C* the movements of the upper valve of the oyster, with a vertical magnification of 7.7 times. All four drums are driven by a common clock-work movement *A* through a horizontal shaft *B* and suitable gearing, the drums making one revolution in 65 hours. Each drum-shaft is prolonged vertically downwards by the rigid attachment of a glass rod *F* reaching to below the orifice at the bottom of the celluloid hopper *H*, the rod terminating in a radially divided dish *G*, dish, rod and drum revolving solidly together. The orifice at the bottom of the celluloid hopper *H*, is so placed that dejecta passed by the oyster within the hopper are directed into that sectorial division of the slowly rotating dish *G* which happens to be beneath the hopper orifice at the time of extrusion.

The speed of rotation of the drum and consequently of the divided dish (since the two revolve together) being known, a rough means of registration is afforded of the times of passage of faeces and pseudo-faeces.

Details of Construction.

Before entering into a detailed description of the ostreagraph, it must be pointed out that the design of the frame-work of the instrument shown in Fig. 1 was influenced by certain local considerations not likely to obtain elsewhere. Those features in the design of the framework which were incorporated on account of these local considerations are valueless in an instrument for general use, and may therefore be eliminated, with a material simplification of construction. Thus on the extreme left-hand side of the instrument, as shown in Fig. 1, the handle can be dispensed with altogether, the left-hand vertical member of the frame-work need not extend above the upper horizontal member, and the two pulleys, shown at the top and bottom respectively of the left-hand vertical member are not required for an instrument of general use, neither are the two nicks in the upper and lower horizontal members of the frame-work, immediately below the pen counterpoise, lettered *E* in Fig. 1. Similar simplification is possible as regards the right hand side (Fig. 1)

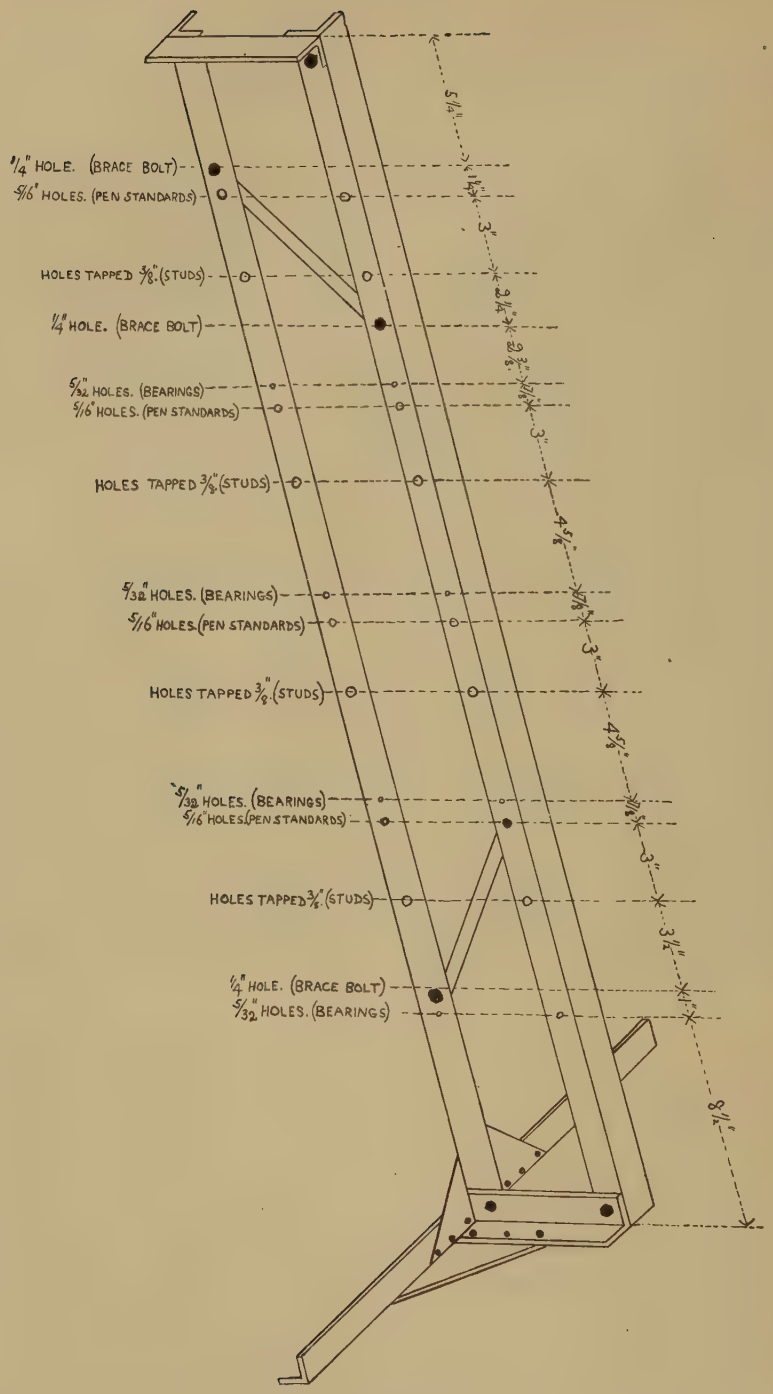


Fig. 2. Frame-work.

of the frame-work. The upper horizontal member may be carried straight along to the vertical member on the extreme right of the photograph, this vertical member and that between it and the nearest drum being cut off level with the upper surface of the upper horizontal member of the frame-work. For general use the nicks near the right-hand extremities of the horizontal members are not required, neither are the pulleys on the extreme right-hand vertical member.

Shorn of these non-essentials, the frame-work of the ostreagraph consists of two horizontal members of $1^1/_4$ inch $\times$ $^3/_{16}$ inch angle-iron, each 4 feet long; three vertical members of the same material, each $6^1/_8$ inches long; a similar piece of angle-iron 19 inches long to form a *T* with the lower horizontal member; and two 45°6 inch angle plates (1), all bolted together with $^3/_8$ $\times$ $^3/_4$ inch steel nuts and bolts (1), as shown in parallel perspective in Fig. 2. This frame-work is strengthened by the addition of two diagonal braces of $^3/_4$ inch $\times$ $^3/_{16}$ inch iron and secured by $^1/_4$ inch nuts and bolts. The positions of attachment of these diagonal braces are shown in Fig. 2, and are of importance, being chosen so as not to interfere with other parts of the instrument. In each horizontal member there are drilled four $^5/_{16}$ inch holes, four $^5/_{32}$ inch holes, and four holes drilled and tapped $^3/_8$ inch Whitworth. The whole instrument stands for steadiness on three points, brass bolts $1^3/_4$ inches $\times$ $^3/_8$ (Whitworth) (1) being tapped into the angle-iron at the extremities of the *T*-shaped part of the frame-work. The assembled frame-work so far as it has been described up to this juncture is shown in Fig. 2.

The drums are made from block-lid or lever-lid tins, $4^1/_2$ inches in diameter and 6 inches high (2). The block-lid is hammered in symmetrically and a small hole pierced in the lid to allow for expansion of air within the tin. Holes $^3/_{16}$ inch are then made in the exact centres of the lid and bottom of the tin. A piece of $^3/_{16}$ inch steel shafting (1) is threaded for about $^1/_8$ inch and a $^3/_{16}$ inch brass nut (3) screwed hard on to it. The shafting is then passed downwards through the holes in the bottom and top of the tin, which is held in the inverted position, the nut soldered to the bottom of the tin (now the top of the "drum") the shaft soldered into the lid of the tin, now the bottom of the "drum" from which $7^3/_4$ inches of shaft protrudes. Each drum-shaft is provided with a "Meccano" collar with set-screw (Meccano Part No. 59) (4) and a $^1/_2$ inch pinion wheel (Meccano Part No. 26A) (4), both reamered out to $^3/_{16}$ inch to slide on the drum-shaft. The correct positions of these two parts on the drum-shaft can be ascertained in the course of assembly and fixed then by means of the set screws, with which both are provided. In use it is

convenient to cover the drums with squared paper, kept in position with rubber bands.

Each drum-shaft runs in a pair of brass bearings fixed vertically one above the other on the front faces of the upper and lower horizontal members of the frame-work. Each bearing is a "Meccano" Hand-rail Support (Meccano part No. 136) (4) reamered out to $^3/_{16}$ inch, the threaded portions of the parts being passed through the eight $^5/_{32}$ inch holes in the horizontal members of the frame-work and secured with the nuts supplied with the parts. The set collars on the drum-shafts take the downward thrust due to the weight of the drums.

All four drums are driven by a horizontal shaft *B* (Fig. 1) running along the top surface of the upper horizontal member of the frame-work, by means of worm-gears on the horizontal shaft in mesh with the pinion wheels on the vertical drum-shafts. The horizontal shaft itself is a piece of $^3/_{16}$ inch steel shafting (1) $35^1/_4$ inches long, and runs in five approximately equally spaced bearings (Meccano parts No. 136) (4) reamered out to $^3/_{16}$ inch, and supported on $^3/_4$ inch lengths of $^3/_4$ inch $\times$ $^1/_8$ inch brass angle (3) bolted to the upper surface of the upper horizontal frame member. The horizontal shaft carries at its left-hand extremity (see Fig. 1) a "Meccano" $^1/_2$ inch pinion wheel, 19 teeth (Meccano part No. 26A) (4), four worm-gears (Meccano parts No. 32) (4) in suitable positions for their enmeshment with the $^1/_2$ inch pinion wheels on the drum-shafts, and a pair of collars with set screws (Meccano part No. 59) (4) hard up against the two sides of any one of the bearings, to prevent end play of the shaft.

The horizontal shaft is driven by a robust 16-day clock-work movement of the kind designed for lighting and extinguishing street gas lamps at predetermined times. The clock-work movement only is obtainable at the cost of £1. 0. 0. from firm (5) (see list in last section). To the main arbor of this clock, which rotates once in 24 hours, a $3^1/_2$ inch, 133 teeth pinion wheel ("Meccano" part No. 27B) (4) is fixed. The clock body, being cylindrical in shape, with the main arbor axially placed, a clock-bracket is conveniently made from two $3^3/_4$ inch lengths of $1^3/_4$ inch $\times$ $^3/_{32}$ inch angle iron (bedstead sides) united parallel to each other by two strips of 1 inch $\times$ $^1/_4$ inch iron. Recesses to take about one-third of the circumference of the cylindrical clock are cut out of the upstanding parts of the angle irons, the distance between which is about $1^1/_4$ inches. The clock is firmly clamped into these recesses by means of a brass strap terminating in a screw and wing-nut (6) engaging in a slot on the outer side of the clock-bracket, for sketch of which see Fig. 3. The clock bracket, the position of which on the instrument will be seen from Fig. 1, is clamped

to the upper surface of the upper horizontal member of the frame-work by means of two $^1/_4$ inch studs let into that member, the studs passing through slots in the clock-bracket so cut as to allow for a backward and forward adjustment of the pinion wheel on the main arbor of the clock in relation to the pinion on the horizontal shaft.

At this point, having described the clock-work movement and the gearing which it actuates, it may be convenient to set down the gear ratios which determine the rate of rotation of the drums. The main

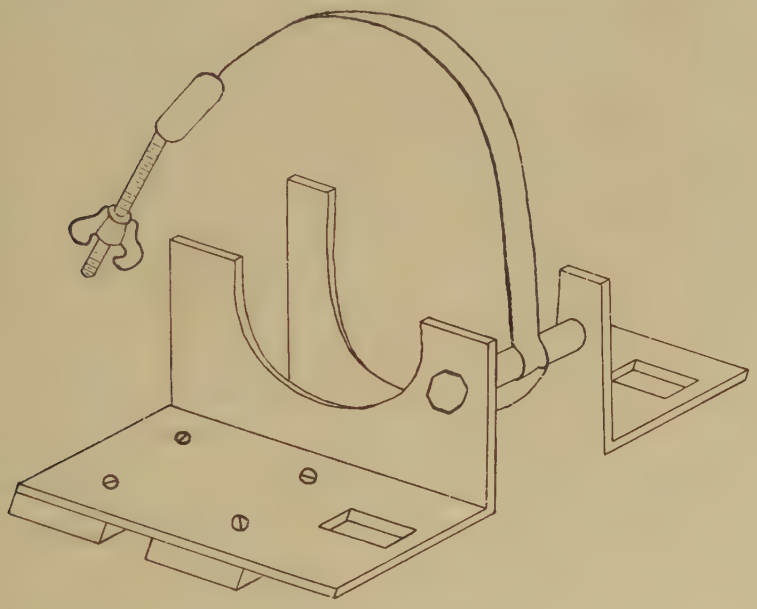


Fig. 3. Clock bracket.

arbor of the clock rotates once in 24 hours. The 133 teeth wheel on the main arbor of the clock drives a 19 teeth pinion on the horizontal shaft. Therefore the horizontal shaft rotates 7 times in 24 hours. The worm-gears on the horizontal shaft engage with 19 teeth pinion wheels on the vertical drum-shafts. The drums, and the revolving dishes rigidly connected with them, consequently make one revolution in 65 hours. The circumference of the drum being 14.3 inches, the hourly travel of the chart attached to the drum is approximately 0.2 inch, that is 2 small squares, if squared paper, divided into inches and tenths, is used for the charts.

The oysters, the celluloid hoppers by which they are partially enclosed, the bearings for the revolving dishes beneath the hoppers and the dish

shafts are all supported on *L*-shaped pieces of slate marked *J* in Fig. 1. These slates are clamped to the upper and lower horizontal members of the frame-work, into which eight $^3/_8$ inch brass studs (made from $^3/_8$ inch screwed rod (3)) are fixed, by means of back-nuts, into the $^3/_8$ inch tapped holes already referred to and shown in Fig. 2, the studs being provided with brass washers (6) and wing-nuts (6). Each slate *L*-piece is about $^5/_8$ inch thick and $45^1/_4$ inches long overall. The long limb is $3^1/_4$ inches broad, the toe being $6^1/_2$ inches broad and 3 inches high. About one and a quarter inches from the outer extremity of the toe, on its upper surface, a glass bearing, made from a piece of capillary tube sealed off at one end, of dimensions such that a gramophone needle runs smoothly in it, is fixed into a hole in the slate by means of "Murrayite" (7). Thirty-one and a half inches vertically above this glass bearing a brass bearing *L* (Fig. 1), a $^3/_{16}$ inch hole in a piece of $^1/_{16}$ inch brass strip (3), is supported on a piece of $^1/_2$ inch $\times$ $^1/_{16}$ inch angle-brass (3), 6 inches long, which is fixed to the slate *L*-piece with brass bolts (3). In these two bearings runs the shaft carrying the radially-divided dish.

These radially-divided dishes are made from Petri dishes, $3^3/_4$ inches in diameter and $^5/_8$ inch deep. A $^1/_4$ inch hole is drilled in the centre of the bottom of the dish by means of a brass tube worked in a brace through wooden guides, the cutting edge of the tube being fed with a mixture of carborundum powder and turpentine. For each dish an ebonite hub is made, consisting of a two inch length of ebonite tube (6), $^3/_4$ inch external diameter and walls $^1/_8$ inch thick. One end of this tube is plugged, by cementing into it with "Murrayite", a $^1/_2$ inch length of ebonite rod (6) which is filed off flush and square with the end of the ebonite tube. Into this plug an axially placed hole is bored and tapped $^1/_4$ inch, into which a piece of threaded $^1/_4$ inch ebonite rod (6) is cemented with "Murrayite", $1^1/_4$ inches of threaded rod being left protruding from the bottom of the plugged $^3/_4$ inch ebonite tube. The protruding threaded ebonite rod is screwed through a central tapped hole of an ebonite disc, $^5/_8$ inches thick (6) 1 inch in diameter, having twelve equally spaced fine saw-cuts, radially arranged, and extending for $^1/_8$ inch inwards from the circumference of the disc. That part of the threaded ebonite rod which protrudes through the disc is passed through the central hole in the bottom of the Petri dish referred to above, which is secured on to the ebonite hub by means of an ebonite nut, between which and the bottom of the Petri dish a rubber washer is interposed. In the screwed $^1/_4$ inch ebonite rod which protrudes beyond the terminal ebonite nut, an axial hole is drilled, of sufficient depth and diameter to admit a gramophone

needle for about half its length. Into this hole the needle is cemented with "Murrayite", point outwards. Radial sub-division of the Petri dish is carried out by cementing with "Murrayite" strips of celluloid, the inner ends of which are secured in the radially-disposed saw-cuts in the hub, the outer ends and lower edges being attached to the periphery and bottom respectively of the Petri dish. The radial celluloid strips are strengthened by cross-halving ("Egg-boxing") a circular celluloid wall concentric with the periphery of the Petri dish, at a radius mid-way between it and that of the ebonite hub. The dish making (with its drum) one revolution in 65 hours, one radial division of the Petri dish will pass a given point in five hours and twenty-four minutes. Into the open end of the $^3/_4$ inch ebonite tube forming the upper part of the hub, a rubber cork is fitted, through which passes a glass rod, which, extending upwards for about 24 inches, terminates in a second rubber cork which fits into a 2-inch length of $^3/_4$ inch (external) ebonite tube, into the upper end of which is cemented an ebonite plug. Into this plug an approximately 2-inch length of $^3/_{16}$ inch brass rod is axially fixed. The gramophone needle in the bottom of the hub of the revolving dish runs in the glass bearing let into the toe of the slate *L*-piece, and the $^3/_{16}$ inch brass rod with which the revolving dish shaft is surmounted, runs in the brass bearing, already referred to (*L*, Fig. 1), and as will be seen by reference to the photograph of the ostreagraph, Fig. 1 (most clearly in the case of the drum, dish etc. on the right of the instrument), that the lower end of the drum-shaft is vertically above the upper end of the corresponding dish shaft. Connection between these two shafts is made by a flexible helical spring, at each end of which is attached a brass electrical screw connector (6). The flexible connection between the two shafts provides compensation in case of slight errors of alignment, which are difficult to avoid. As an alternative to spring connections, "Meccano" Universal Couplings (Meccano part No. 140) (4) could be used.

The next items for description are the celluloid hoppers each of which directs the dejecta extruded by the oyster within it into that division of the revolving dish which happens to be beneath the hopper orifice at the time of extrusion. The hoppers, the shape and dimensions of which are shown in Fig. 4, are secured by rubber bands, as shown in Fig. 1, to the slate *L*-pieces, which are cut away sufficiently to bring the orifices of the hoppers into proper relation to the revolving dishes. As an alternative material for the construction of the hoppers, "Staybrite" Steel (8) Sheet, (with soldered joints might be used).

The oysters under experiment are rigidly fixed by their lower valves to suitably bent iron rods, which are bolted to the *L*-shaped slates, each

rod being so shaped as to support an oyster in its normal position within its hopper *H* (Fig. 1), without interfering with the connecting rod *I* (Fig. 1) which is attached to the upper valve of the oyster. Prior to an experiment, a $^3/_{16}$ inch flat-head bolt is attached to the lower valve of an oyster by means of Portland cement, which is allowed to set for about a day out of water, followed for a few days in sea-water. By using Roman cement the time of the oyster out of water can be reduced to an hour or two, and it is possible that by the incorporation into Portland cement of a proprietary setting-accelerator sold under the name of "Sika" (9) of which, however, the writer has no practical experience, that the cement would be finally set and the oyster ready for experiment in the course of a few minutes. When the cement has set, the

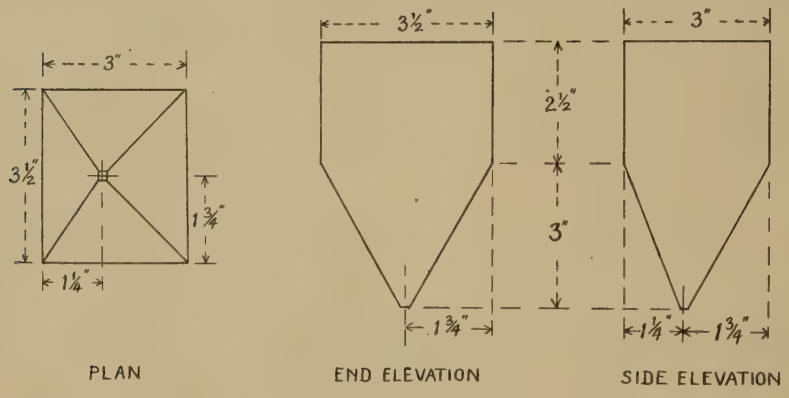


Fig. 4. Celluloid hoppers.

$^3/_{16}$ inch iron screw on the lower valve of the oyster is passed downwards through a hole at the end of the iron rod and fixed by means of an iron nut.

At the time of the cementing of the screws to the lower valves of the oysters, as just described, the socket parts of simple ball and socket joints are cemented to the upper valves. These ball and socket joints each consist of two "Gillette" safety razor blades, broken off about $^1/_8$ inch above the central circular hole, and united parallel to each other, with the interposition of a distance piece of iron $^1/_8$ inch thick, by a bolt and nut through their remaining straight-sided holes. An oyster having been fixed by the screw on its lower valve to the iron support, a $^5/_{16}$ inch steel ball (rustless balls (10) are now obtainable) to which is soldered a few inches of $^1/_{16}$ inch steel rod, (3) is sprung into the socket formed by the circular holes in the two parallel razor blades, with of course a liberal coating of vaseline. A sketch of this ball and socket

joint is given (Fig. 5). The steel rod soldered to the ball forms the lower extremity of the connecting rod *I* (Fig. 1), by which the movements of the upper valve of the oyster are communicated to the pen *D* (Fig. 1) and is extended upwards by the attachment to it, by means of Plaster of Paris, of a glass tube, reaching to above the water line. At this point it is joined to a $^1/_{16}$ inch brass rod connected with the ball of the ball and socket joint of the pen (to be described later) by means of a clamp

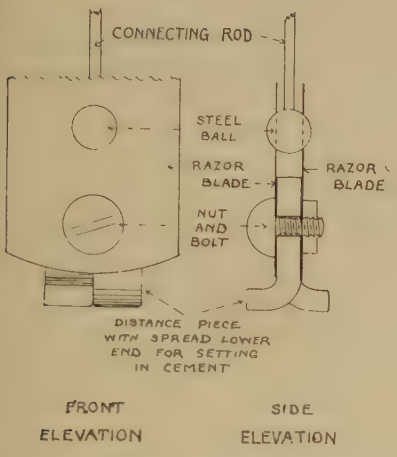


Fig. 5. Ball-and-socket joint for cementing to oyster.

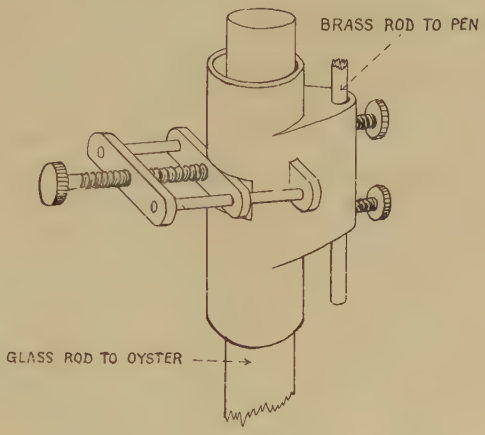


Fig. 6. Screw clamp for connecting rod.

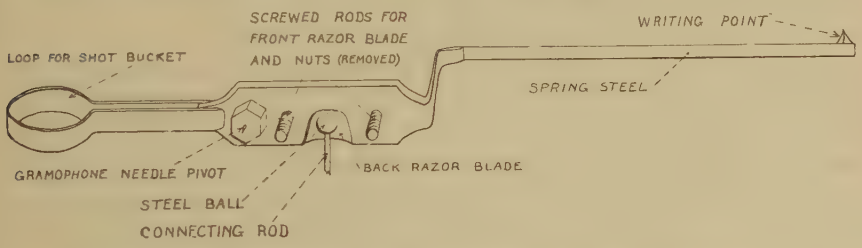


Fig. 7. Pen (front razor blade and nuts which hold it removed).

made from an electrical screw connector, a piece of brass tube and a small screw clip, which fitting, shown in Fig. 6, allows of the easy adjustment of the length of the composite connecting rod.

The last parts of the instrument to be described are the pens and their supports. The body of each pen is made from a 3 inch length of $^3/_4$ inch $\times$ $^1/_8$ inch brass flat (3), through which is soldered, $^5/_8$ inch from one end, a piece of $^3/_8$ inch hexagon brass rod (3) of such a length that it projects $^1/_4$ inch on each side of the brass flat (see Fig. 7). A small

central hole is drilled in each end of the brass hexagon, of sufficient diameter and depth to admit a gramophone needle, which is soldered in, point outwards, the needle points working in depressions, to be described later, forming the pivots upon which the pen turns. At $^1/_2$ inch and $1^1/_2$ inch centres respectively from the vertical plane of the gramophone needles, lengths of $^3/_{16}$ inch brass screwed rod (3) are soldered into tapped holes in the $^3/_4$ inch $\times$ $^1/_8$ inch brass flat, and cut off to leave $^3/_8$ inch of screwed rod projecting from each side of the brass flat, which is cut away between the screwed rods as shown in Fig. 7. A Gillette Safety razor blade, with one cutting edge ground off flat and the other hollowed out as shown in Fig. 7, is passed over the two projecting screwed rods on one side of brass flat and kept in place by means of $^3/_{16}$ inch nuts, which should, however, be smaller than standard $^3/_{16}$ inch nuts, and which are obtainable from (3). A similarly ground razor blade is slipped over the pair of projecting screw rods on the other side of the brass flat. The two circular holes of the now parallel blades form the socket of the ball-and-socket joint through which the movements of the upper valve the oyster are communicated to the pen by the connecting rod (*I* Fig. 1) already described, the ball being a $^5/_{16}$ inch steel bearing ball, to which is soldered a 12 inch length of $^1/_{16}$ inch brass rod (3); which is connected to the glass portion of the connecting rod by means of the clamp referred to above and shown in Fig. 6. To the end of the pen body further from the gramophone needles, the flexible spring arm, which keeps the writing point up to the drum, is attached. The plane of the spring arm is off-set 1 inch behind (in regard to aspect of the instrument as shown in Fig. 1) the plane of the main body of the pen, by soldering it to a suitably bent piece of $^1/_4$ inch $\times$ $^1/_{16}$ inch (3) brass strip, which is soldered to the main pen body (see Fig. 7). The pen arm is made from an approximately 5 inch length of thin spring steel, $^3/_{16}$ inch broad (3), at the distal end of which is a V-shaped gutter pen, made from the thin brass foil used by motor engineers for making "Shims" for packing up worn bearings. The ink used in this pen is that supplied for use in thermographs; the lever ratios are such that the valve movements of the oysters are recorded on the drums with a vertical magnification of 7.7 times. To the end of the pen body nearer to the gramophone needles a loop, made from $^1/_4$ inch $\times$ $^1/_{32}$ inch brass flat (3) is soldered, to take a $2^1/_2$ inch $\times$ $^7/_8$ inch test-tube (*E* in Fig. 1), the axis of the test-tube being $2^5/_8$ inches from the vertical plane passing through the two gramophone needles. This test-tube contains sufficient shot to counterpoise the pen, the whole of the connecting-rod and the ball-and-socket joint cemented to the oyster, the adjustment being made, of

course, with the connecting rod etc., immersed to the extent to which they are to be submerged in actual experiment.

The adjustable bearings, together with their supports in which the gramophone needle pivots of the pens turn, are made by the adaption of brass battery clamps No. 211 (11). Such a battery clamp, after the necessary modification, is shown in Fig. 8. Each battery clamp is bolted in the position there shown to an 11 inch length of 1 inch $\times$ $^1/_8$ inch

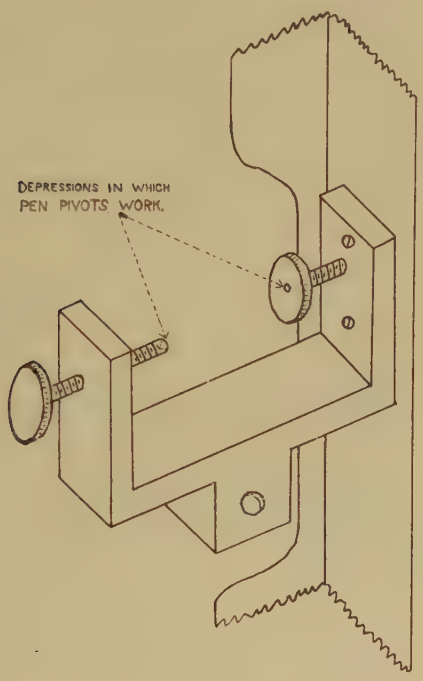


Fig. 8. Pen bearings.

angle iron (3), cut away to admit of the free working of the pen. The back surfaces (in regard to the aspect of the instrument shown in Fig. 1) of these angle iron pen standards are off-set 3 inches in front of the front surfaces of upper and lower horizontal members of the frame-work, each standard being rigidly attached thereto by two $^5/_{16}$ inch iron rods threaded at both ends and provided with two pairs of nuts. The screwed rods pass through the four pairs of $^5/_{16}$ inch holes shown in the horizontal frame-work members in Fig. 2, and through corresponding holes in the pen standards. The adapted battery clamps are so positioned on the pen standards that the axis of rotation of the pens (produced) is $1^3/_4$ inches above the upper surface of the upper horizontal frame members. The

pen standards also serve to support brass screw terminals (*M* Fig: 1) in which suitably bent lengths of $^1/_{16}$ inch steel rod (3) may be clamped

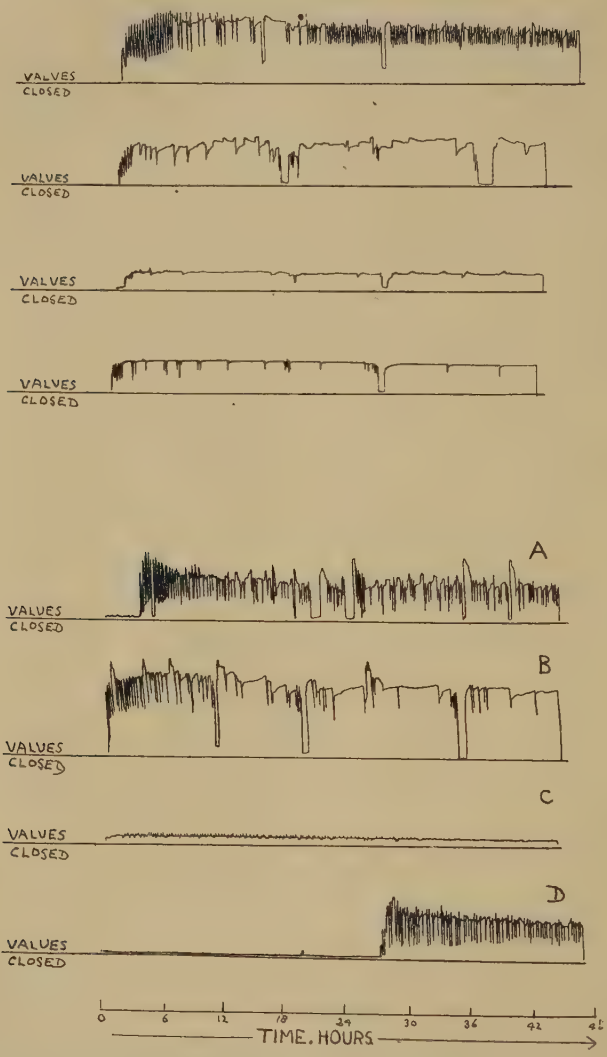


Fig. 9. Tracings of the valve movements of two batches of four oysters each. All the oysters of each batch had the same history, and were under identical conditions whilst the tracings were being taken. Valve excursions magnified 6.6 times.

to subserve the purpose of keeping the pens away from the drums whilst the charts are being changed.

The writer would here wish to acknowledge the valuable assistance which he has received at the hands of his colleagues, Mr. H. P. Sher-

wood and Mr. Horace Lees. To Mr. Sherwood he is indebted for the design and construction of the celluloid hoppers, and also for the photograph of the ostreagraph (Fig. 1) and for Figs. 4, 5, 6 and 7. To Mr. Lees he is similarly indebted, for the great skill and care which he brought to bear on the construction and adjustment of those portions of the instrument which he undertook to make, notably the revolving parts.

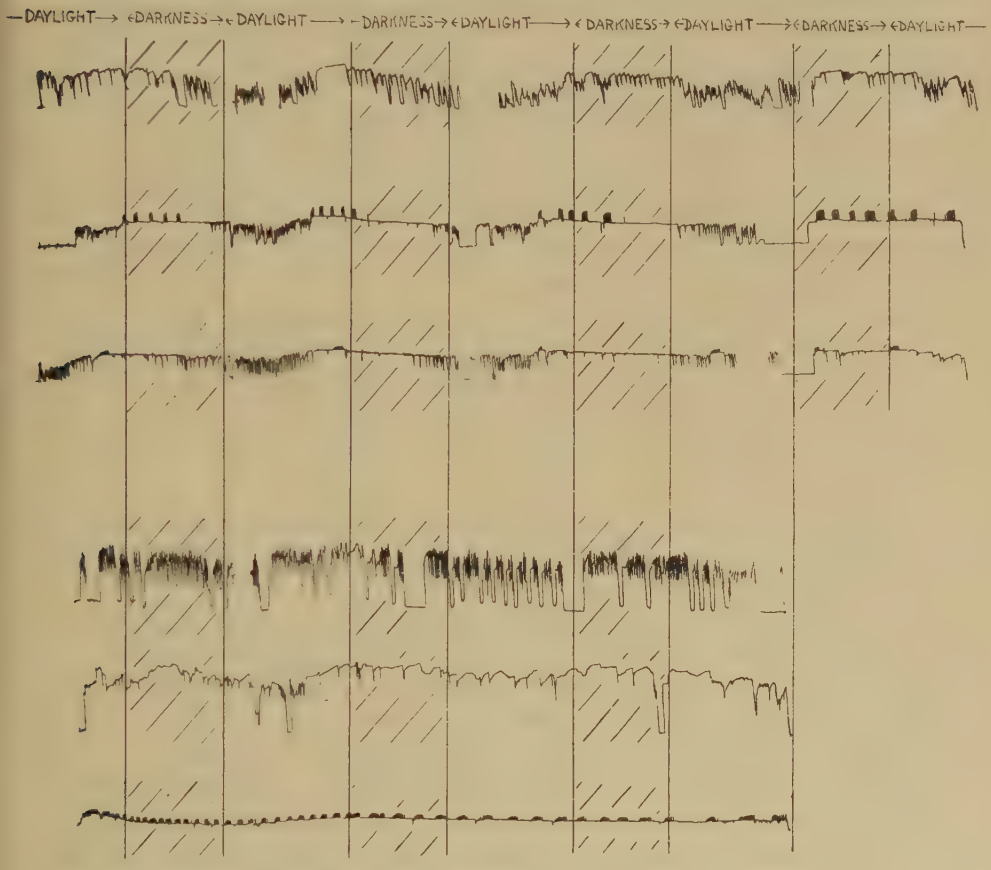


Fig. 10. Influence of daylight and darkness on the behaviour of oysters. Valve excursions magnified 6.6 times.

Results obtained.

For the reasons which have already been set forth, the volume of information obtained by the application of the method of autographic record to the observation of the valve movements of oysters is not large, and inasmuch as on the completion of the construction of the dual purpose apparatus, as stated above, at a late stage of the investigation, the

necessity for certain modifications of that part of the instrument designed for the registration of the times of the extrusion of dejecta was indicated, it has been possible up to the present to do no more in the direction of experiments on the times of extrusion of dejecta than to try out the part of the apparatus designed for that purpose. The performance, however, of that part designed for recording the valve movements was satisfactory from the beginning, as was that of the original apparatus, and, it may be of interest to give a few examples of the experiments carried out, and the results obtained with the autographic recorders.

The first two sets of tracings to be mentioned, shown in Fig. 9, have already been referred to. The oysters in question were all part of the same delivery, stored together in an open tank of 2700 gallons capacity, with frequent changes of water, for about two months, at the end of which time they were transferred, in successive batches of four, to a similar but covered tank, connected with the recording apparatus, and allowed to function undisturbed, in the dark, for about 48 hours at a depth of 12 inches of water, S.G. 1025, of maximum and minimum temperatures respectively of 52°—47° F. in the case of the first four oysters, and 54°—47° F. in the case of the second four. It will be seen from the tracings shown in Fig. 9, in the cases of both batches of oysters, that although, as regarded the four oysters comprising each batch, their past history for the previous two months and the conditions obtaining whilst the tracings were being taken, were identical, their behaviour as judged by their valve movements, was by no means so.

The tracings shown in Fig. 10 indicate that the onset and termination of daylight have little influence on the behaviour of oysters, as judged by their valve movements. The tracings were obtained by connecting to the recording apparatus, in batches of three, six oysters which were allowed to function at the bottom of an open tank 3 feet deep and 12 feet × 12 feet superficially, filled with sea-water of S.G. 1025. In the case of the first three oysters the tracings of which are shown in Fig. 10, the duration of the experiment and the temperature range of the water were respectively about 96 hours and 50°—46° F. and in the case of the second three oysters about 72 hours and 54°—47° F. The periods of darkness are indicated by the shaded portions of the charts.

It was a matter of some interest in connection with the general question of oyster purification to ascertain the influence of immersion in fresh water on the subsequent behaviour of oysters. In Fig. 11 are shown tracings which were obtained in two experiments in that direction. In the first of these, in which the upper four tracings shown in Fig. 11 were obtained, two oysters, to serve as controls, were immersed in sea

water, of S.G. 1025, for 46 hours, the temperature range over the period of immersion being 46°—41° F. Two other oysters were immersed for the same period in a bowl of fresh water partially submerged in the water of the above-mentioned sea-water tank, so that the temperature con-

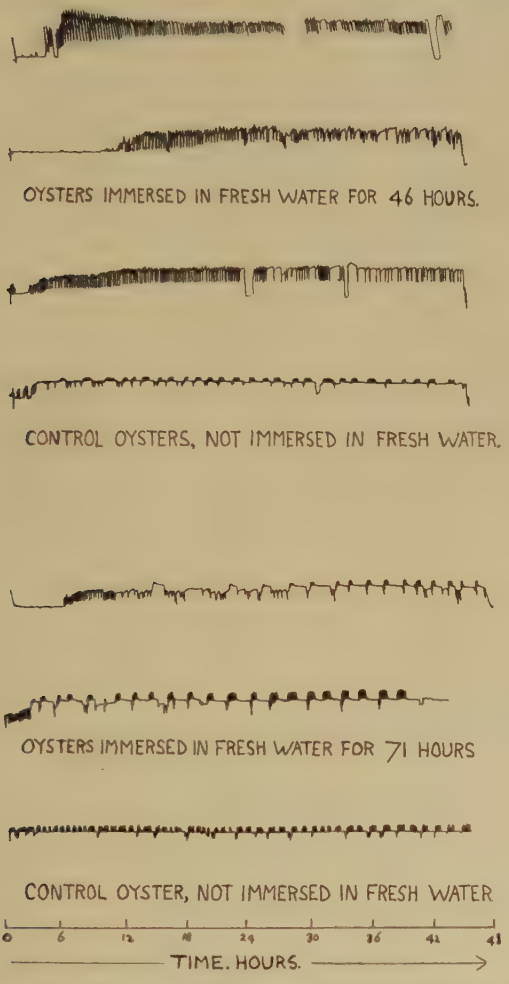


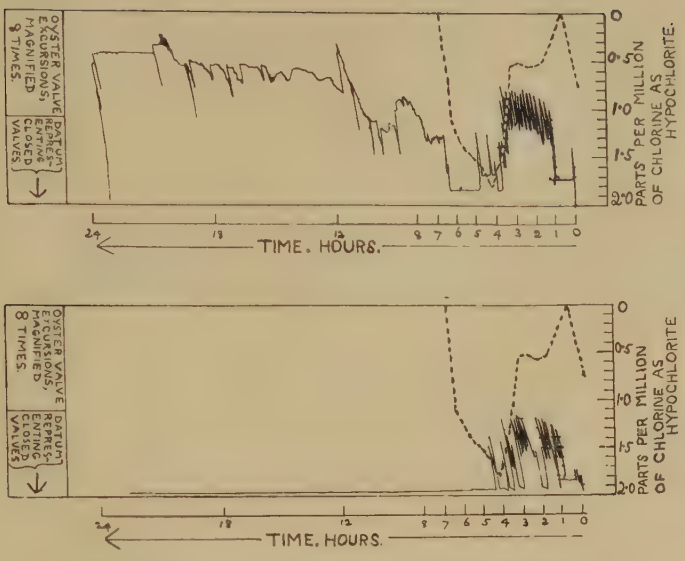
Fig. 11. Influence on the behaviour of oysters of immersion in fresh water. Valve excursions magnified 6.6 times.

ditions of the fresh water in the bowl and of the sea-water in the tank in which it stood were the same. Immersion was carried out in darkness. At the end of the immersion period, all four oysters were connected to the recording apparatus, set up over two 20 litre bowls, in one of which the oysters which had been immersed in fresh water were placed, in the

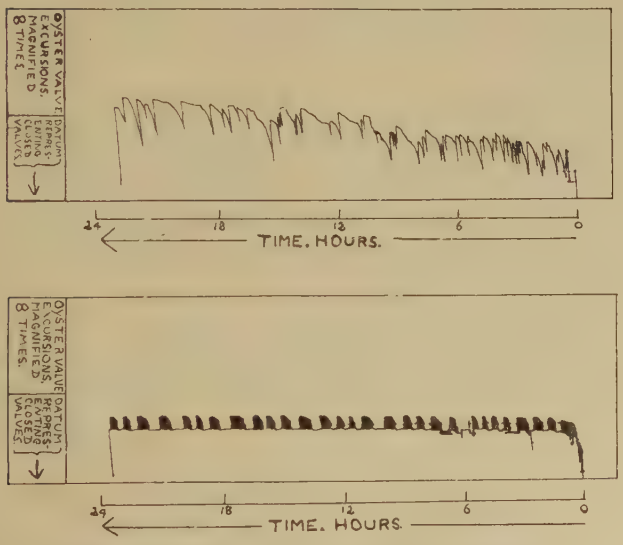
other the controls; both bowls being filled with sea water of S.G. 1025. The oysters were allowed to function in darkness for about 46 hours, over which period the temperature range of the water in both bowls was 53°—47° F.

In the second experiment of the same kind, in which the lower three tracings shown in Fig. 11 were obtained, a similar procedure was followed. The period of immersion of the oysters was, however, 71 hours, the temperature range over the immersion period 45°—41° F., and that over the period 48 hours, during which they were subsequently allowed to function undisturbed, in connection with the recording apparatus 50°—48° F. (The tracing given by one of the control oysters used in this experiment was rendered worthless by a defect in the pen which developed during the course of the experiment). From a comparison of the behaviour of the oysters which had previously been immersed in fresh water with that of the controls, as demonstrated by the tracings shown in Fig. 11, it might perhaps be said that there appears to be a tendency towards delay in opening on the part of oysters previously immersed in fresh water. Against this suggestion, however, must be set the findings of the experiment in which the lower four tracings shown in Fig. 9 were obtained. In that experiment not only were all four oysters under identical conditions whilst connected to the recording apparatus, but had identical histories extending back for the previous two months. Yet, as will be seen from the tracings in question, which have been lettered for convenience of reference *A*, *B*, *C* and *D* (Fig. 9), that the oyster furnishing tracing *B* opened widely as soon as connected to the apparatus and remained open until the time of disconnection, the oyster furnishing tracing *C* opened very slightly over the whole period of the experiment, whilst the oysters furnishing tracings *A* and *D* for no apparent reason delayed their opening until approximately 4 hours and 29 hours respectively had elapsed after their connection to the recorder.

The lack of uniformity of behaviour amongst oysters was also observed in an experiment on the action on them of "chlorine", that is, hypochlorite. In the experiment in question two oysters were placed in a 20 litre bowl through which a slow current of sea water of S.G. 1025 at a temperature of 51° F. was caused to flow. Through a similar bowl, in which were placed two other oysters, a similar current of sea-water of the same specific gravity and temperature, but containing a small concentration of hypochlorite, was likewise caused to flow. All four oysters were connected to the recording apparatus, by which the tracings shown in Fig. 12 were obtained. Arrangements were made for varying at will the hypochlorite concentration, which was estimated at frequent



OYSTERS IN WATER CONTAINING HYPOCHLORITE.



CONTROL OYSTERS. NO HYPOCHLORITE.

Fig. 12. The influence of small concentrations of hypochlorite on the behaviour of oysters.

regular intervals by the usual method. On the appropriate tracings shown in Fig. 12 the hypochlorite concentrations have been plotted. It will be seen that whatever relation may have obtained between the behaviour of the oysters and the concentration of hypochlorite whilst the latter was operative, when the hypochlorite feed was shut off, the oyster furnishing the uppermost tracing (Fig. 12) opened widely and remained open for the duration of the experiment, whilst the other oyster which had been subjected to the action of hypochlorite under exactly parallel conditions, shut during the peak period of hypochlorite concentration never to re-open during the remainder of the period of the experiment.

Names and Addresses of Firms from which Components not easily obtained locally may be purchased.

The number against each firm corresponds to the number (in brackets) following the component supplied by it on its first mention in the Section devoted to details of construction.

(1) Metal Agencies Co., Ltd., Queen Square, Bristol.
(2) Messrs. John Feaver, Ltd., Tower Bridge Road, London, S.E. 1.
(3) Mr. J. Heath, 459, Romford Road, Forest Gate, London, E. 7.
(4) Messrs. Meccano, Ltd., Binns Road, Liverpool. (Also agencies in most towns.)
(5) The British, Foreign and Colonial Automatic Light Controlling Co., Ltd., 100, Holdenhurst Road, Bournemouth.
(6) The Economic Electric Co., Ltd., 10, Fitzroy Square, London, W.
(7) Messrs. Flatters & Garnett, 309, Oxford Road, Manchester.
(8) Messrs. Thomas Firth & Sons (Birmingham) Ltd., Blackheath, Birmingham.
(9) Sika Ltd., 82, Victoria St., London, S.W.
(10) Messrs. Stuart Turner, Ltd., Henley-on-Thames.
(11) Messrs. A. Gallenkamp & Co., Ltd., 19, Sun Street, Finsbury Square, London, E.C. 2.

Paper and Glass Collectors for Oyster Spat.

By

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In the spring of 1929, in order to meet the requirements of new methods of oyster breeding suggested by that season's investigations and their results, certain preliminary tests were made at Lympstone with a view to finding a more efficient and a lighter oyster spat collector than the limed tiles generally in use. Such collectors might, it was hoped, be modified if necessary and used during the 1930 season.

Amongst the materials employed were paper and glass.

Large glass bottles were chosen. From some, the small paper labels were removed before use, but those which had large thin paper labels gummed to their sides were limed with these labels attached. Thin labels (similar to the adhesive luggage variety) were specially singled out, as being probably the most easily removed when desired. Sixteen-ounce window glass was also requisitioned, but this was used plain, no paper being gummed to it. The object aimed at by the combined glass and paper tests was the ultimate removal of the paper *en bloc* with the spat attached. This could then be quickly broken up into pieces with the individual oysters attached.

The lime mixtures used for the coating of these collectors were as (a) and (b) below:—

(a) 1 lime, 1 mud, 1 sand
(b) 1 lime, 2 mud, 1 sand.

Two coats were employed, the (a) mixture being the more efficient, as it held the labels on better. These lime mixtures were stirred with water to a medium creaminess, lumps being carefully excluded. The bottles, after liming, were both sunk and floated upwards in the tanks, at suitable depths.

A good spatfall having occurred, many young oysters were found attached to all the collectors after June 26th.

When rapid growth began, where the spat had settled upon the limed labels, it was noted that the overcrowding problem had solved itself, as the young oysters had pushed each other off to a great extent. Herein lay the virtue of adopting thin paper. Having a thin layer of gum beneath, already thoroughly soaked by long immersion, which helped the paper to slide about the smooth glass surface below, the pressure of the growing shells coming together loosened the spat. In many cases this process advanced so far that the spat fell off individually and in small groups of 2, 3 or more. Detroquing was very rapidly carried out, with great facility and no damage.

Concerning the window glass, it was found that the spat settled upon the limed coating of this, and also detroqued very well, especially when the specimens had attained a measurement of 1.0 cm. or more. One push with the point of a knife below the umbo was sufficient, and each specimen came away leaving the glass visible in clean round patches.

The spat in this case, however, did not detroque themselves, nor could more than three specimens be detached at a time, even when favourably placed. In the case of labels it was possible to peel off large portions whole, with spat attached, where thick settlement had not already broken up the paper.

Proceeding on the lines indicated by these tests, certain collectors have been and are in process of being constructed for this season's experiments; as follows:—

1) Paper gummed on glass and limed:
2) Sheets of brown paper, not too stiff, hung over 8″ cylinders of 1″ wire netting; the whole being dipped in a mixture of 1 lime, 1 sand, and 1 cement. The cylinders are to be hung from their centres, with their axes parallel to the ground, and the paper will be allowed to hang free for a short distance below the cylinders. These have dried out sufficiently rigid for the purpose and appear very promising. (It has already been proved that galvanized wire netting, limed and covered with a slate, and stood on end, makes an excellent collector; one of this type, 8″ in diameter and 9″ high, bearing 703 living spat, easy to detroque — many of which, in fact, fell off on touching the collector — so that the use of similar netting in conjunction with paper seems justified.)
3) Blotting paper has also been used in the same way, but great care is necessary when applying the first coat of lime.

Both types of paper collector described above remain rigid in water, but neither have yet been tested with spat upon them, of course, as they are designed for use during the present season.

The above tests are being carried out at the British Ministry of Agriculture and Fisheries tanks at Lympstone, in South Devon.

Reviews.

Essay-Review.

The Production of Clean Shellfish.

By J. H. Orton.

The Report on Mussel Purification[1]) by Dr. R. W. Dodgson is the outcome of extensive researches made at the direction of the Ministry of Agriculture and Fisheries, England, with the object of evolving a practical and economic method of placing living mussels (*Mytilus edulis*) on the market as a sound food-product. The report describes the means by which that end was attained, and also gives a survey of the fundamental problems bearing on the sewage pollution of shellfish from the point of view of Public Health.

It was known that mussels may be unsuitable as food from at least two entirely different causes, namely (1) a vaguely defined toxicity due to the physiological condition of the mollusc itself and (2) the possibility of the bivalve carrying and passing on to the consumer harmful bacteria, whilst remaining otherwise healthy and sound. The author's medical training and experience enabled him to attack these problems at an advantage, while the report abounds in instances of his patience and ability to meet and assess the value of the practical difficulties which were encountered in devising an economic scheme of purification.

Dr. Dodgson's researches into the recondite literature of diseases due to eating mussels are summarised as follows:—

"1) 'Mussel poisoning', as generally understood, connotes any indisposition following the consumption of mussels; with the exception of the most important, namely, those due to specific (e. g., bacterial) infections, such as typhoid fever.

2) The widely held popular view that all manifestations of poisoning, due to the consumption of mussels, arise from a common cause, inherent in mussels, is erroneous.

3) 'Mussel poisoning' includes at least three pathological conditions, or types of conditions, namely:—

[1]) Report on Mussel Purification. Min. of Ag. and Fish. Fishery Invest. Series II, Vol. X, No. 1, 1928. London, 1928.

a) 'Musseling', or the erythematous form, which is due to properties inherent in the mussels. It affects a limited number of specially susceptible people, who should avoid eating mussels. The symptoms are of short duration, and unpleasant whilst they last; but are never of serious import.
b) The paralytic form, always grave and even fatal. Its cause is not definitely known, but it is always due to mussels from foul or stagnant waters. It is extremely rare (some 8 to 10 cases only being on record). The danger of contracting it may be reduced to such small proportions as to be probably entirely negligible, if elementary precaution be exercised; and especially if only purified mussels be eaten.
c) The bacterial food-poisoning form. If purified mussels only be eaten, the risk is probably not greater than that attaching to the consumption of other meat or milk foods, or even food in general.

4) Mussels, in common with other shellfish, and fish in general, contain a certain amount of arsenic, and may contain copper; but evidence that illness may be caused by these substances is lacking.
5) Certain popular conceptions, that poisonous properties reside in the 'beard', foot, or other parts of the mussel, are erroneous."

Thus the author shows that most of the diseases arising solely from the physiological constitution or condition of mussels may be avoided by the consumption only of the purified bivalve, whose origin can be vouched for. Some human individuals have a constitution to which mussels are inimical, and should therefore never eat mussels; while none should eat mussels from stagnant waters, such as occur frequently in docks. The mode of death — when death occurs — from eating mussels from these latter situations is by asphyxia, and it is at least a striking correlation that the respiratory centre in man (and other warm-blooded animals) should be affected by some substance produced in mussels that have been living in a situation where lack of oxygen is probably of common occurrence. As Dr. Dodgson has shown that mussels can live as long as 24 days under anaerobic conditions, it would seem that in the lack of oxygen this mollusc produces in its tissues (liver ?, Dodgson) some substance (Mytilotoxine, Brieger), which possibly controls but is certainly connected with the metabolism of the tissues under anaerobic conditions. It would appear that this substance retains and imposes an analogous influence on the tissues when transferred to man, with, however, lethal effect. Further researches on this problem offer a promising field to the human physiologist.

After disposing of the relatively minor troubles due to eating mussels, the author attacks the main source, namely, diseases due to specific infections, e. g. typhoid and related fevers, incurred by eating the uncooked flesh.

The evidence for the transmission of these diseases by bivalves in general and by the mussel and the oyster in particular is given and critically examined. The conclusion is arrived at that although absolute proof — such as might be obtainable from *ad hoc* feeding experiments on man —

of transmission is not available, yet "the evidence in question is such as to establish the causal relationship between the consumption of polluted shellfish and typhoid fever, beyond reasonable cavil or doubt". In this view the author is supported by many distinguished Medical Officers of Health (see also Journ. Roy. San. Institute, Nov. 1928, p. 283).

Thus the problem of producing a sound food-product in living mussels was reduced to that of freeing otherwise healthy molluscs from any typhoid or related bacteria; or other harmful material, which they may have taken into themselves from waters polluted by sewage or other noxious substances.

Academic researches had shown that the mussel and other economic bivalves feed in a simple manner on the organic material suspended in the surrounding water. This method is essentially as follows:— The shell space around the body of the bivalve is divided into two chambers between which the gill or beard is suspended as a partition. The gill is perforated by slits or holes and is furnished with various sets of microscopic whips or cilia. Certain sets of cilia beat rhythmically in one direction to maintain a large flow of water through first one chamber, then through the slits in the gill into the second chamber and finally out of the shell. Other sets of cilia on the gill arrest all or most of the particles in the water-stream and thus the gill acts as a very fine sieve. The collected food-particles are conveyed by other sets of cilia on the gill towards the mouth. If the collected food material is apparently suitable as food it is eaten, if it is not suitable, it is usually rejected by a special mechanism. It follows from the mode of feeding, that bivalves take into the shell-spaces from the surrounding water all kinds of finely-suspended material.

In order to obtain bivalves free from bacteria, it was therefore necessary to devise a method of treatment which would result not only in the removal of the entire gut-contents, but would also wash the shell-spaces, and in addition the outside of the shell, free from bacteria. By a series of experiments the author proved that a functioning mussel will evacuate ingested gut-contents in one and a half hours if the ingestion of food-material be continuous, and that under the conditions eventually established for purification the gut-contents are always evacuated (macroscopic observations) in one night's treatment in a sample cleansing tank. Extensive bacteriological analyses of mussels purified in test-cleansing tanks also proved that virtual if not actual purity was attainable, and a practicable economic scheme was devised.

This scheme has been applied on a commercial scale at Conway for a period of twelve years; it has been tested and improved, and under competent supervision may now be regarded as an established practical economic method of placing living mussels on the market as a sound food-product.

The principle of the method of purification is simple: freshly collected bivalves, which have, however, been out of water for some hours, are immersed overnight in a large volume of freshly »sterilised« sea-water. In two such successive immersions — with an intermediate tank-cleaning process — mussels *purify themselves* to the highest standard of purity. (It has been found, however, that oysters require three such immersions to attain a similar degree of purity.)

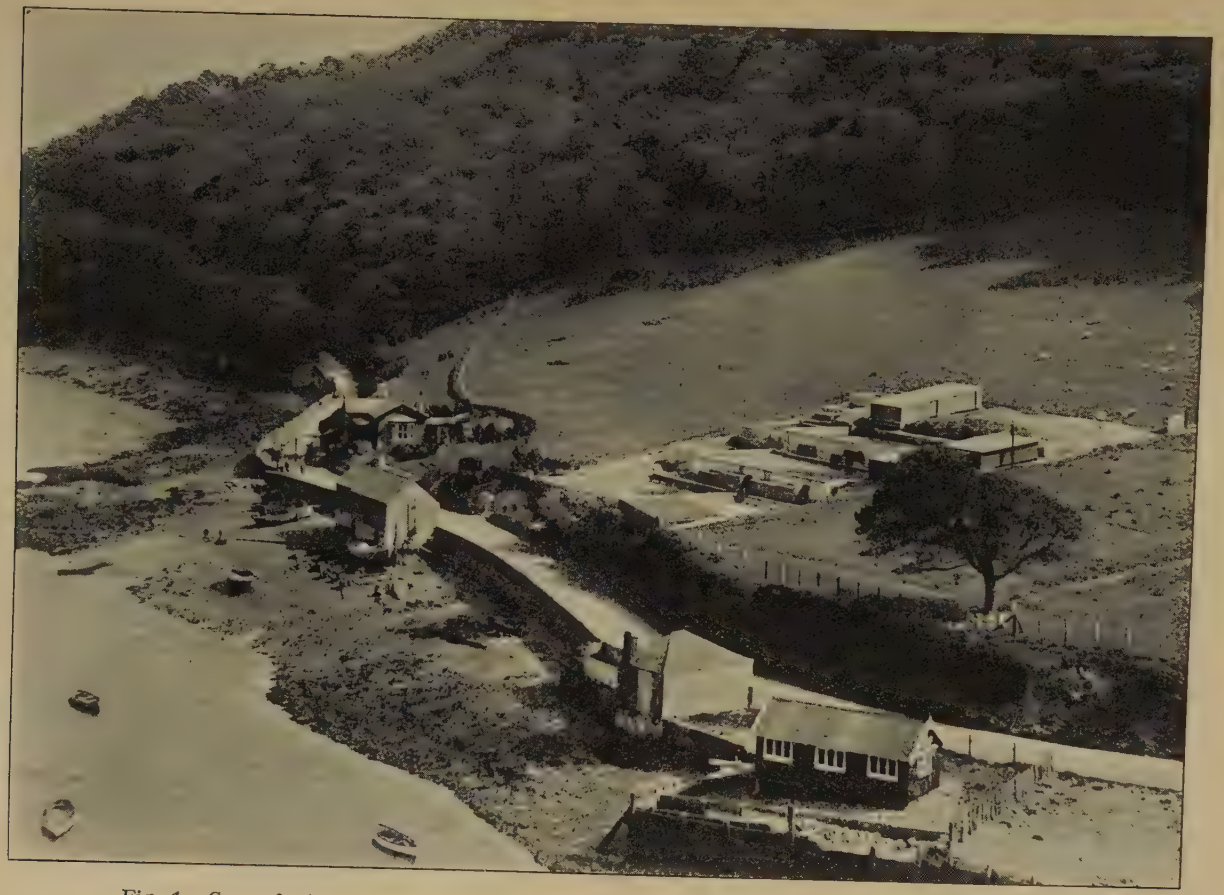

Fig. 1. General view of mussel purification installation and experimental tanks at Conway.

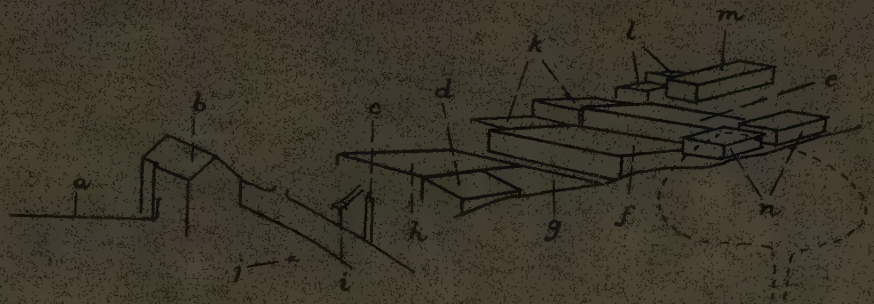

Fig. 2. Explanatory diagram of Fig. 1.

a Intake main. *b* Engine house and office. *c* Lift. *d* Mussel shed. *e* STORAGE TANK. *f* CHLORINATING TANK. *g* and *h* CLEANSING TANKS. *i* Chute for loading carts. *j* Drain exit from tanks. *k* and *l* Open tanks for oyster experiments. *m* Covered tanks for oyster experiments. *n* Sheds for oyster tiles.

A brief description of the commercial method is as follows. The plant in use for the scheme at Conway is shown in Fig. 1, and in skeleton form in Fig. 2. For mussel purification three large tanks (*e*, *f*, and *g* or *h*, in Fig. 2) are used in series. Tank *e* is a store tank and receives untreated sea-water; Tank *f* is used only for the operation of sterilising the sea-water; Tank *g*, or alternatively Tank *h*, serves as the cleansing or purifying tank. The shellfish which are to be purified are first well washed by a high pressure jet of water from a hose, then placed in the empty cleansing tank *g* on wooden grids. In the meantime the untreated water in tank *e* is run into tank *f* and at the same time mixed with a solution of bleaching powder in such quantity as will give an estimated potential concentration of 3 parts in a million of available chlorine when the tank is full. The amount of chlorine added is sufficient (in this locality) to sterilise the water (as regards non-sporing bacteria) and leave an excess. Therefore, when tank *f* is prepared it contains sterilised sea-water with a certain amount of chlorine in a state which might be harmful if it were added to the shellfish. The excess of harmful chlorine is, however, got rid of by treating the water from tank *f* with sodium thiosulphate as it is run into tank *g*. Thus tank *g*, after receiving the shellfish to be cleaned, is filled up with sterilised and innocuous water. In this water the shellfish, that is mussels or oysters, or other kinds, open freely and gradually clear their alimentary canal and shell-spaces of harmful bacteria and other products. To facilitate the removal of faeces and other rejected products, the grids containing the shellfish are raised from the bottom of the tank, so that when the tank is emptied the products rejected by the bivalves can be cleared from the bottom of the tank before the next dose of sterilised water is added. In this way mussels contaminated to the extent of 500 to 600 sewage bacteria per c.c. of minced mussel and shell-liquor can be purified constantly to a standard of only 1 to 4 residual, but not necessarily sewage, bacteria per c.c. Similar results have been obtained with oysters after 3 days' treatment, and so far as is known, in both cases, without any loss of commercial value. The tanks used are very large; *e* and *f* each having a capacity of 80,000 gallons, and *g* a capacity of 40,000 gallons. These tanks have enabled about 20,000 quarts or 16 tons of mussels to be cleansed per week at a cost to the fishermen of ls. per bag of 140 lbs.

Before being packed in sterilised bags for transport to the market, the mussels are treated for not more than one hour in a bath containing three parts of available chlorine in order to sterilise the outside of the shell. From the time the mussels are collected on the foreshore to their dispatch in bags after purification not more than four days are normally required.

The whole process of purification has been worked out in detail meticulously, and regulations are given for directing and safeguarding every stage of the operation. The author is insistent upon the fact that the bivalves purify themselves in clean water, and herein lies the simplicity and the brilliancy of the scheme. The earlier methods of purifying bivalves by the use of free chlorine relied on the direct action of this reagent upon the water in which the bivalves themselves were immersed; in Dodgson's method free chlorine is never in contact with the bivalves during the essential and internal purifying process. Fabre-Domergue evolved a scheme

for the self-purification of oysters in filtered running water, and Johnstone and Scott later tried a similar scheme for mussels, but no one has used the author's combination of sterile water with subsequent self-purification. The earlier workers on the subject will readily perceive the advantages of the new method, and it is interesting to note that a train of research workers back to Johnstone, Fabre-Domergue, Klein, Herdman and Boyce have contributed to its fruition.

The final solution of the problem was not attained, however, without a large amount of original detailed investigation by the author into the

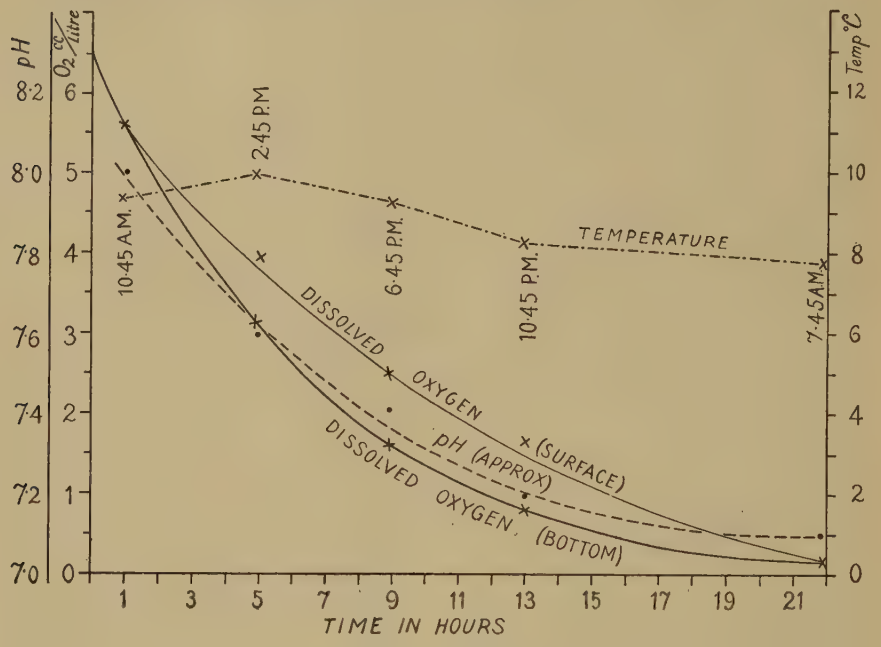

Fig. 3. Variation in oxygen content, *pH* and temperature in a mussel cleaning tank during a second day of treatment.

biology and physiology of the mussel, into bacteriological methods and, indeed, engineering problems. To the biologist the section of the report on "The physiology of the mussel with special reference to purification" (pp. 154—222) is a revelation in the study of habits. One astonishing result given in this section is reproduced in Fig. 3 above. The graphs given in this figure show the reduction in the oxygen content at the surface and the bottom of the water (ca. 1 metre deep) covering a batch of mussels in the purifying tank during the second day of treatment, in October. The amazing fact emerges that in a large tank with a large surface of water exposed to the air, practically all the oxygen is used up by the active mussels within about 21 hours. It seems probable that this single observation may be exploited to give far-reaching results in hydrobiology. Similar delightful pieces of work are recorded in this section; for example,

mussels are shown to be sensitive to light, and "can only be relied upon to open and function (i. e. produce water currents and feed) in the dark, or in very subdued daylight. Hence in the cleansing operations it is stipulated that "the mussels must have 'one night' in the tanks during each phase of the process". Mussels may function at any temperature between 0° and 26° C., but as a rule show no signs of so doing at 0° in daylight though they will begin at the same temperature as soon as it is dark or nearly dark. Below 0° they may or may not function in the dark, but have been observed to pass faeces at — 1.5° C.; they may be so completely frozen that no liquid shell-liquor can be detected, and yet recover in a short time, if thawed slowly, even though the mantle and surface of the body may have been frozen. Oysters, it was noted, are more sensitive to low temperatures than mussels and in general require different treatment in the purifying tanks.

It is an interesting fact that mussels appear to function as vigorously at low as at high temperatures, in spite of the fact that the cilia on the excised gill-filaments show a marked slowing-up of beat at low temperatures. The functioning of mussels in daylight at low temperatures is so uncertain that a rule was established in the cleansing procedure that the water must not fall below 39° F. (= 3,9° C) during at least one night of the treatment in the tank.

On another page the author gives reasons why the so-called liver may have at times an excretory as well as a digestive function.

In another and more important section of the report the author deals with "certain general considerations and suggestions regarding the sewage pollution of shellfish in its Public Health aspect". The existing system of defining pollution solely on the results of bacteriological analysis is attacked and condemned by means of experiments, observations and reasoned argument. It will probably be admitted by everyone that a living bivalve, taken from an estuarine situation, can never be stated dogmatically to be entirely free from those bacteria which are the same as, or indistinguishable from, those inhabiting the human intestine. Hence any "standard of purity" must be arbitrary; and the author proves that the published standards, upon which action is taken to condemn or condone shellfish and their beds of origin, are unsound. Regulations for the control of shellfish and their beds of origin may therefore be regarded as being in the melting-pot. The present time is therefore a convenient one in which to review the whole subject from an international as well as from a national point of view. In a problem of this kind it is certain that valuable information of an empirical kind is available, and can be collected — with mutual goodwill — and utilised for the solution of the general problem. This problem includes:—

1) the need for a clearly defined and recognised standard of purity in bivalves or, alternatively, the beds or other situations from which the bivalves are taken for consumption;
2) the classification of existing beds under recognised standards of purity or impurity;
3) a clear definition of the administrative body which is responsible for applying the standards.

In these investigations the reviewer has already suggested (Journ. Roy. San. Instit., Nov. 1928) that it would be advisable to include among the investigators in England, representatives of the Fishmongers' Company, the Ministry of Health, the Ministry of Agriculture and Fisheries and, for the topographical work, either a marine biologist or a hydrographer who is familiar with biological as well as hydrographical variations in estuarine situations.

The increasing sewage pollution in estuaries which formerly held a high standard of purity also calls for action from the point of view of Public Health and of relieving everyone concerned from anxiety.

The report is provided with a comprehensive list of contents; an excellent author and subject index, and bibliography; topographical maps of three important mussel beds; photographs of the tanks in the various stages of purification of mussels at Conway; photographs of critical bacteriological culture plates and original drawings of mussels in various stages of functioning. There is an Appendix by H. Marshall Webb, on the formation of glucose in minced mussels and oysters on incubation. The author has well repaid the confidence and the magnificent support given to him by the Fishery Department of the Ministry of Agriculture and Fisheries.

J. N. Carruthers. The Water Movements in the Southern North Sea. Part III. The Area off the Wash. (a.) The Flow of Water past the Inner Dowsing Lightvessel. Ministry of Agriculture and Fisheries. Fishery Investigations. Series II. Vol. IV. No. 6. London 1929. 36 S.

Wie immer mehr erkannt wird, hat der Reststrom eine erhebliche Bedeutung für die Verfrachtung von Fischlaich und die Schwankungen des Reststromes sind vielleicht sogar von Einfluss auf die Alterszusammensetzungen der Nutzfische. Da in dem Gebiet vor dem Wash-Busen Heringslaich in erheblichen Mengen abgesetzt wird, sind die dortigen Restströme fischereibiologisch von Interesse. Es sind deshalb von dem dort befindlichen Inner Dowsing Feuerschiff aus Reststrombeobachtungen mit dem Strommesser von Carruthers gewonnen worden in gleicher Weise wie auf dem Varne Feuerschiff (vergl. Journal du Conseil IV, S. 234—236), also in 6 Faden Tiefe. Die Beobachtungen begannen wie auf Varne F. Sch. im Juni 1926 und wurden bis Oktober 1928 durchgeführt, sie erstrecken sich demnach über einen Zeitraum von mehr als zwei Jahren. Im Oktober 1928 wurden die Arbeiten abgebrochen, dafür wurden auf dem 26 Seemeilen ostsüdöstlich gelegenen Cromer Knoll Feuerschiff gleiche Beobachtungen begonnen, die ebenfalls zwei Jahre hindurch fortgesetzt werden sollen. Die Arbeiten auf Inner Dowsing Feuerschiff sind also jetzt abgeschlossen, ihre Bearbeitung liegt in oben genannter Veröffentlichung vor. Die gesamten Beobachtungen sind für den ganzen Zeitraum von 751 Mondtagen gleich 777 gewöhnlichen Tagen veröffentlicht; die einzelnen Messungen beziehen sich meist auf zwei, selten auf einen oder drei Mondtage. Zur Gewinnung einer Übersicht über die Ergebnisse wurden die mittleren Restströme für jeden Monat und jede einzelne Jahreszeit berechnet sowie ausserdem

die mittlere monatliche sowie jahreszeitliche Wasserversetzung abgeleitet. Der mittlere Reststrom während der ganzen Beobachtungszeit war mit 1,04 sm pro Mondtag oder Doppeltide nach N 27° W gerichtet, die Geschwindigkeit war kleiner als 40 % der bei Varne-Feuerschiff festgestellten in die Nordsee gerichteten Wasserbewegung. Die Mittelwerte für die einzelnen Jahreszeiten weichen von diesem Generalmittel erheblich ab, so herrscht im Mittel im Sommer ein Reststrom von 1,26 sm/Tag nach N 65° W, im Herbst von 1,92 sm/Tag nach N 36° E, im Winter von 1,02 sm/Tag nach N 2° W und im Frühjahr von 1,48 sm/Tag nach N 55° W. In den Einzelmonaten oder gar an den einzelnen Tagen waren die Abweichungen noch erheblich grösser. Eine Beziehung des Reststromes zu der Wetterlage festzustellen, gelang nicht. Doch sollen die Untersuchungen hierüber wieder aufgenommen werden, sobald auch die Beobachtungen von Cromer Knoll-Feuerschiff vorliegen.

Da bei den Beobachtungen die Zahl der in die einzelnen 16 Fächer des Strommessers gefallenen Kugeln bestimmt wurde, sind auch Schlüsse auf die mittlere Richtung der Gezeitenströme möglich, wenn sich auch die Dauer und die Eintrittszeit der einzelnen Stromrichtungen nicht feststellen lässt. Im Mittel ist der Flutstrom nach N 10° W, der Ebbstrom nach S 10° W gerichtet. Die Einzelwerte weichen von diesem Mittel zum Teil erheblich ab. Eine Untersuchung der Beziehungen zum Winde ist noch nicht durchgeführt. Weiterhin lässt sich aus der Zahl der gefallenen Kugeln auch der Betrag der gesamten während einer Tide erfolgten Wasserbewegung feststellen. Dieser Wert beträgt im Mittel der 751 Mondtage 9,12 sm für einen halben Mondtag. Der gesamte während einer Tide vom Wasser zurückgelegte Weg schliesst ausser den Gezeitenbewegungen auch den Reststrom ein. Der niedrigste Wert wurde für Januar 1928 mit 6,77, der höchste für September 1928 mit 11,40 sm/Tide gefunden. Dieser Gegensatz ist besonders auch deswegen bemerkenswert, weil die gleichzeitigen Restströme keine erheblichen Abweichungen von einander zeigten.

Endlich ist auch wenigstens für den Gesamtzeitraum die Wasserversetzung nach den einzelnen 16 Richtungen bestimmt und damit die mittlere Gezeitenellipse, allerdings ohne Eliminierung des Reststromes abgeleitet worden. Es ergibt sich ein Überwiegen des Ebbstromes über den Flutstrom im Betrage von etwa $^1/_2$ sm/Tide entsprechend dem oben angegebenen Betrage des mittleren Reststromes.

Es ist zu erwarten, dass die auf Cromer Knoll Feuerschiff im Gang befindlichen Beobachtungen das gewonnene Bild wesentlich vervollständigen werden. Im übrigen kann man dem Verfasser nur zustimmen, wenn er die Forderung aufstellt, dass von allen noch in Betrieb befindlichen hölzernen Feuerschiffen aus derartige Reststrombeobachtungen über einen längeren Zeitraum hin durchgeführt werden. Bruno Schulz.

V. Walfrid Ekman. Über die Strommenge der Konvektionsströme im Meere. Lunds Universitets Årsskrift. N. F. Avd. 2; Bd. 25; Nr. 6; Lund 1929.

Die Ausbildung einer rationellen Theorie der Meeresströmungen ist fast ausschliesslich ein Verdienst von V. W. Ekman. Er hat in einer grossen

Zahl von Untersuchungen in folgerichtiger Entwicklung die einzelnen Stromkonstituenten der Meeresströmungen, die auf innere und äussere Kräfte zurückzuführen sind, festgestellt und gezeigt, wie diese zusammengesetzt werden müssen, um das Bild des »Elementarstromes«, das die Verteilung der Stromrichtungen und der Geschwindigkeit in allen Punkten einer Vertikalen geben soll, zu erhalten. Die drei verschiedenen Konstituenten sind in kurzen Worten folgende: 1. der reine Triftstrom, hervorgerufen durch den mitschleppenden Einfluss der Luftströmungen (innere Reibung samt Turbulenzreibung). Er reicht bis zur sogenannten »oberen Reibungstiefe«. 2. der Staustrom entsteht ohne Windeinfluss bei einer derartigen Neigung der Meeresoberfläche und der isosteren Flächen, dass der Druckgradient in allen Tiefen proportional der Dichte wird. Er setzt sich zusammen aus dem gleichmässigen Tiefenstrom und dem Bodenstrom. 3. der Konvektionsstrom ist ein Strom, der den vorhergehenden Konstituenten hinzuzufügen ist, wenn Oberfläche und isostere Fläche die tatsächliche Lage im Meer einnehmen.

Die Bewegungsgleichungen für diese Konstituenten sind aus früheren Arbeiten Ekmans bekannt. In der praktischen Ozeanographie bestimmt man die Konvektionsströme zumeist nach dem bekannten aus dem Bjerknesschen Wirbelsatz abgeleiteten Lehrsatz von Helland-Hansen. Er gestattet, aus dem Massenfeld nur die Grösse und Richtung der relativen Geschwindigkeit der Schichten gegeneinander ohne Berücksichtigung der Reibung zu ermitteln. Triftströme können, als durch Reibung hervorgerufen, natürlich dadurch nicht erfasst werden, und die berechneten Konvektionsströme können vielleicht etwas, aber nicht in starkem Masse fehlerhaft werden. In der vorliegenden neuen Arbeit gibt nun Ekman eine Methode an, aus dem Massenfeld die Strommengen eines Konvektionsstromes anzugeben, wobei der durch Vernachlässigung der Reibung auftretende Fehler ganz wegfällt. Unter Strommenge wird bekanntlich die in horizontaler Richtung in der Zeiteinheit verschobene Wassermenge verstanden, mathematisch der horizontal gerichtete Vektor S, dessen Achsen-Komponenten

$$S_x = \int \varrho u dz \text{ und } S_y = \int \varrho v dz \text{ sind}^1).$$

Die Integrale sind von der Meeresoberfläche ($z = 0$) bis zum Boden ($z = d$) zu nehmen. Bei Strommengen innerhalb einer bestimmten Wasserschicht ändert sich das Integral-Intervall. Wendet man nun die hydrodynamischen Bewegungsgleichungen der einzelnen Konstituenten des Elementarstromes bei einem Meer an, das aus einer »Deckschicht« der Tiefe d_i, die stets grösser als die Mächtigkeit der baroklinen Oberfläche Oberflächenschicht ist, und aus einer barotropen Unterschichte besteht,

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[1]) Es bedeuten: ϱ die Dichte, u und v die zu x und y parallelen Komponenten des tatsächlichen Stromes, z die dynamische Tiefe, ausgedrückt in dyn. Metern, p der Druck, p_i der Druck in der dyn. Tiefe d_i, beide ausgedrückt in Dezibar. Die Grösse $\frac{\varrho}{\varrho_i}$ ist abhängig von z, aber doch meistens in so geringem Masse, dass ein Mittelwert ε gesetzt werden kann; $c = \frac{1}{2\omega \sin \varphi}$, g die Schwere.

so lässt sich in relativ einfacher Weise die Strommenge des auf die Deckschichte beschränkten Konvektionsstromes aus dem Massenaufbau berechnen[1]).

Die Ableitung soll hier nicht gegeben werden, nur das Resultat. Die Strommengekomponenten des Konvektionsstromes sind gegeben durch die Beziehung

$$S'''_x = -\frac{100\,c}{g}\frac{\partial P}{\partial y} \text{ und } S'''_y = \frac{100\,c}{g}\frac{\partial P}{\partial x}, \text{ worin } P = \int_o^{d_i} (-\varepsilon p_i + p)\, d_z \text{ ist.}$$

Die Grösse P ist eine Funktion von x und y und kann benutzt werden, um die Strommenge des Konvektionsstromes graphisch in ähnlicher Weise darzustellen, wie die dynamischen Isobathen einer isobaren Fläche. Aus einem gegebenen Massenfeld kann P zahlenmässig ermittelt werden und es lassen sich dann aus diesen Zahlen Niveaulinien für äquidistante Werte von P zeichnen (Strommengekarten). Der Vektor S''' folgt dann überall der Richtung dieser Niveaulinien und zwar liegt die Richtung der Strommenge *contra solem* zu der Zuwachsrichtung für P. Die Grösse der Strommenge ist für eine gegebene geographische Breite umgekehrt proportional dem Abstande zweier benachbarter P-Linien. Werden die P-Linien für alle ganzzahligen Werte von P ausgezogen, so transportiert der Konvektionsstrom z. B. quer durch einen in 45° Breite zwischen zwei aufeinanderfolgenden Linien gelegten Vertikalschnitt pro Sekunde 98,900 Tonnen Wasser.

Dieser neue Lehrsatz von V. W. Ekman ist für die dynamische Ozeanographie ausserordentlich wichtig. Er gibt vor allem die Strommenge mit Berücksichtigung der Reibung und gleichzeitig die wirkliche Richtung des Wassertransportes im Konvektionsstrome, also nicht etwa relative Werte an. Eine einzige Strommengekarte für ein Meeresgebiet legt den Wassertransport innerhalb eines Gebietes fest, die Stromkarten müssen hingegen für alle Schichten gezeichnet werden, und nur eine grosse Zahl derselben kann die Strommengekarte ersetzen. Zwar enthält diese weniger Einzelheiten als die Stromkarten.

In der praktischen Anwendung tritt eine Schwierigkeit insoweit auf, als eine Zweiteilung, barokline Deckschicht und homogenes Tiefenwasser, meist nicht vorhanden ist. Die Schiefstellung der Isosteren gegen die Isobaren nimmt zwar mit der Tiefe ab, aber sie verschwindet nirgends vollständig. In die für eine bestimmte Tiefe d_i berechnete P-Linien-Karte geht dann nicht der ganze Konvektionsstrom ein, aber bei möglichst grosser Wahl von d_i lässt sich die Hauptsache desselben wohl erfassen. Natürlich muss d_i kleiner als die Bodentiefe sein, um einigermassen richtige Werte zu erhalten.

V. W. Ekman hat als Beispiel einer solchen Berechnung einer Strommengekarte einige Beobachtungen (18 Stationen) aus dem nördlichen Golfstromgebiet benutzt, die in der Abhandlung von Helland-Hansen und Nansen »The eastern North-Atlantic« enthalten sind. Zunächst zeigt

[1]) Ein Massenaufbau ist barotrop bezw. baroklin, wenn die isobaren und isosteren Flächen zusammenfallen, bezw. nicht zusammenfallen.

er, dass in den obigen Formeln anstelle der Drucke p_i und p auch die sogenannten Druckanomalien gegenüber einem homogenen Meer von 0° und 35 ‰ genommen werden können. Als Tiefe d_i der Deckschichte wählt er 1000 dyn. m. Die konstruierte Strommengekarte entspricht im wesentlichen den sogenannten Isobaren-Karten in der Abhandlung von Helland-Hansen und Nansen; die P-Linien zeigen, wie die dynamischen Isobathen, die kräftige Ausbuchtung nach Süden, die bekanntlich als Wirkung einer morphologischen Beeinflussung des Bodenreliefs auf die Meeresströmungen angesehen wird. Insofern nur die Schichte Oberfläche bis 1000 m Tiefe berücksichtigt wird, werden hier im südlichen Teil der Karte (etwa 47° N. Br.) etwa 2 Millionen Tonnen, im nördlichen Teil (etwa 66° N. Br.) rund 1,6 Millionen Tonnen Wasser per Sekunde transportiert.

Ohne Zweifel wird bei zukünftigen dynamischen Berechnungen von ozeanographischem Beobachtungsmaterial die Ermittlung der Strommengekarte eine grosse Rolle spielen und uns so einen weiteren Einblick in die Dynamik der Konvektionsströme gewähren. A. Defant.

J. E. Fjelstad. Ein Beitrag zur Theorie der winderzeugten Meeresströmungen. Gerlands Beiträge zur Geophysik. B. 23, H. 3. Leipzig, 1929.

S. F. Grace. Internal Friction in Certain Tidal Currents. Proc. Roy. Soc., A, vol. 124. London, 1929.

In the theory of ocean currents the internal friction between the water strata moving on top of one another has proved to play an important rôle. With internal friction should then be understood not only the molecular viscosity due to the irregular free motions of the individual molecules but chiefly the enormously intenser effect of turbulence, i. e., of irregular motions of larger or smaller masses of water. As a rule it has been assumed that this latter effect can be interpreted as an "eddy viscosity" acting in a similar way to molecular viscosity; so that their combined effect may be correspondingly expressed by a "virtual coefficient of viscosity", which would everywhere be much greater than the coefficient of molecular viscosity and would vary considerably from one place to another according to conditions. For the sake of mathematical simplicity, and in the absence of any other reasonable particular assumption, most oceanographers have assumed this coefficient to be constant along any vertical line.

In later times several writers have endeavoured to do without this conventional assumption, either replacing it by the more general assumption of a variable coefficient or even rejecting altogether the idea of a virtual viscosity. According to the latter view the effect of turbulence on the mean motion may be equivalent to a tangential stress, which does not, however, necessarily act in the direction of shear or vanish in case of no shear. This view has become of more actual interest in face of the important researches of L. F. Richardson, according to which the eddies of turbulence — in any case in the atmosphere — may have different dimensions up to very large ones. For it is obvious that it is not strictly possible to express the effect of turbulence in terms of viscosity, if the distances covered by individual masses of turbulently moving water (corresponding to the

mean free path in the theory of gases) are not very small as compared to all other linear dimensions appearing in the problem.

I wish in these remarks to call notice to some contributions tending towards the theoretical development here referred to.

Fjelstad in his paper keeps to the conception of (eddy-) viscosity though with a virtual coefficient which may vary in any way along the vertical. An interesting formula is given, by means of which this coefficient may be calculated for any level whatever, if the velocity and direction of motion are known (by observation or by interpolation) everywhere from the level in question down to the bottom. The validity of the formula is restricted to the case of stationary, pure drift currents; *i. e.*, the horizontal pressure gradient is assumed to be *nil*. On the other hand it requires no derivations except one derivation of the direction of motion, and it is therefore more convenient and better suited to give accurate results than the corresponding methods developed by Th. Hesselberg in 1919 and by H. Solberg in 1925.

The author applies his method to the currents observed by H. U. Sverdrup in 1924 at a station north of Siberia, or really to the average motion there during a tidal period. Furthermore he gives an interpolation formula with two parameters for the virtual kinematic coefficient of viscosity

$$\nu = \nu_0 \left(\frac{z+\varepsilon}{h+\varepsilon}\right)^{0.75},$$

where z and h are the depths from the sea surface down to the water layer under consideration and to the sea bottom respectively, and where ν_0 and ε are parameters. The formula proved to fit the computed values of ν very well. From these values the author back-calculates the velocities of the current in the several levels. There is good agreement between the calculated and the observed velocities, which implies an additional verification of the computed values of ν. [The same series of observations has been analysed before by means of Hesselberg's formula but not with quite as good results (H. U. Sverdrup. The Waters on the North Siberian Shelf. Bergen, 1929)].

The paper by S. F. Grace deals with tidal currents and more particularly with the semi-diurnal lunar harmonic constituent of these currents and of the friction in certain places, chiefly in the North Sea. It owes its interest mainly to the fact that the author has in a way made himself independent of the conception of viscosity.

Two alternative assumptions are made. One is so far in accordance with the notion of viscosity that the tangential stress is assumed to vanish in each level where the velocity is stationary with depth. The other, suggested by G. I. Taylor, is that the tangential stress vanishes at the sea surface but not necessarily at such levels where the velocity is stationary. The latter assumption is strongly at variance with common conceptions, but it is in reality the more plausible one (for, since an harmonic constituent of tidal currents only is concerned, the tangential stress of the wind must be supposed to be effectively eliminated), and it would have been extremely interesting to have had it put to a conclusive test. Unfortunately

— as the author has himself emphasised — the series of observations at disposal is rather scanty, and is not likely to be sufficient for that purpose.

The author attempts to calculate, by means of an interesting method, the components of frictional force acting in different levels. It should be remarked that, since his method is essentially based upon the commonly accepted non-linear relationship between skin-friction and velocity at the bottom, the semi-diurnal harmonic constituent of the friction cannot be expected to be entirely predominant, even if that would be the case with the corresponding constituent of the velocity as compared to its other harmonic and irregular constituents. This circumstance — as well as the possibility of not inconsiderable errors connected with certain inevitable extrapolations — reduce the importance of the present results. The paper is presented by the author as a preliminary survey only, and a closer study of the subject will certainly be looked for with great interest.

V. Walfrid Ekman.

George F. McEwen. A Mathematical Theory of the vertical Distribution of Temperature and Salinity in Water under the Action af Radiation, Conduction, Evaporation, and Mixing due to the Resulting Convection. Bull. Scripps Institution of Oceanography, La Jolla, Cal., Techn. Ser. Vol. 2, Nr. 6, pp. 197—306, 11 figures in text, University of California Press, Berkeley, Cal.

Die Arbeit ist eine Erweiterung und Vertiefung früherer Arbeiten des Verfassers, besonders einer zur 50-Jahrsfeier der Universität von Californien 1918 erschienenen Schrift, die sich mit dem kalten Auftriebwasser an der Californischen Küste beschäftigte. Selten wird eine mathematische Theorie fähig sein, den physikalischen Vorgängen ausgedehnter Gewässer im Einzelnen zu folgen; vielmehr wird sie stets vereinfachende Annahmen machen müssen, um der Probleme Herr zu werden, und deshalb hängt die Anwendbarkeit einer solchen Theorie nicht nur von ihrer mathematischen Eleganz ab, sondern davon, in welchem Grade die zu Grunde gelegten Annahmen sich den wirklichen Verhältnissen anpassen. Gerade in diesen Grundannahmen geht daher der Verfasser über seine früheren Arbeiten hinaus. Die Sonnenstrahlung dringt nur wenige Meter tief ein; die Weiterleitung der Wärme übernehmen vertikale Strömungen und turbulente Vorgänge, während die Oberfläche sich durch Leitung, Strahlung und Verdunstung, am stärksten durch letztere, abkühlt, jedoch nicht überall gleichmässig, sondern fleckenweise verschieden stark. Dadurch werden einzelne Wasserteilchen spezifisch schwerer und sinken ab; aber auch hierzu ist allerdings nach dem Verfasser notwendig, dass der Unterschied des spezifischen Gewichtes erst einen gewissen Schwellenwert überschreiten muss, ehe ein Teilchen sich in Bewegung setzt. Nun denke man sich die Unterschiede zwischen der Dichte der sinkenden Wasserteilchen und der ihrer Umgebung nach ihrer Grösse geordnet; dann werden am seltensten solche Teilchen vorkommen, die relativ am schwersten sind, und umgekehrt; andrerseits dagegen werden sie sich am schnellsten abwärts bewegen. McEwen's Grundvorstellung besteht also darin, dass bald hier Gruppen von relativ schweren Teilchen in grossen Abständen und schnell, bald dort Gruppen von relativ nur wenig

schweren Teilchen in geringen Abständen und langsam, niedersinken. Dem steht gegenüber ein Strom leichterer Teilchen nach oben. Man sieht ohne weiteres ein, dass die »Basic Equations«, die diese Vorgänge beschreiben, ziemlich verwickelt sein müssen.

Die Folge davon ist, dass der Verfasser in den drei Beispielen, die die zweite Hälfte der Arbeit ausmachen, gezwungen ist, vereinfachende Annahmen über die Turbulenz, den vertikalen Strom usw. zu machen, da diese Grössen noch zu wenig bekannt sind; er wählt u. a. Exponentialfunktionen, und nimmt für die Zahl der absinkenden Teilchen das aus der statistischen Mechanik bekannte Maxwell'sche Verteilungsgesetz an. Damit berechnet er für den Lake Mendota bei Madison (Wisc.) aus 20jährigen Temperaturbeobachtungen für die Monate Mai bis September die durchschnittliche monatliche Abkühlung, ausgedrückt durch die ihr entsprechende Verdunstungshöhe, 5,65 cm, während die Einstrahlung einer solchen von 24,5 cm gleichkommen würde; für die Turbulenz ergibt sich die im Vergleich zu Bestimmungen von W. Schmidt recht kleine Zahl 0,85 c.g.s., die zum September hin noch bis auf 0,016 abnimmt. Ein zweites Beispiel bezieht sich auf stündliche Beobachtungen in einem in der Scripps Institution aufgestellten quadratischen Becken von fast 2 m Seitenlänge und etwa 1,5 m Tiefe, bei dem auch die vom Boden absorbierte Strahlung berücksichtigt wird; die beobachtete mittlere stündliche Verdunstung, 0,25 mm, stimmt annähernd zu der theoretisch berechneten. Endlich unterzieht McEwen die der Arbeit von 1918 zu Grunde liegenden Beobachtungen der Wassertemperaturen bei den Coronado-Inseln einer nochmaligen Berechnung auf Grund der neuen Theorie. Es zeigt sich, dass danach der Wert der Turbulenz wesentlich kleiner ausfällt (3,6 im Mittel statt 30 nach der älteren Theorie); ebenso ist die Geschwindigkeit, mit der das kalte Tiefenwasser aufquillt, nur 15 m im Monat, während früher für sie 53 m und 31 m berechnet waren. Angesichts der nicht ganz einheitlichen Beobachtungen wird man aber wohl zufrieden sein müssen, dass wenigstens die Grössenordnung erträglich stimmt, ohne freilich den Wunsch zu verhehlen, dass die Theorie der Austausch- und Mischungsvorgänge durch Beobachtungen in Bälde auf eine sicherere Grundlage gestellt werden möge. H. Thorade.

W. R. G. Atkins and H. H. Poole. The Photo-chemical and Photo-electric Measurement of Submarine Illumination. Journ. Marine Biol. Assoc. N. S., Vol. XVI, No. 2, pp. 509—514, Plymouth 1930.

The paper under review gives an account of measurements made in 1928. The photo-sensitive substance used in previous determinations in daylight consisted of a 0.1 N-solution of oxalic acid, approximately 0.01 M with respect to uranyl sulphate $UO_2SO_4 3H_2O$. The concentration of uranyl sulphate used in the submarine measurements was 4.27 g. per litre.

After exposure of the solution in quartz, or glass, test tubes the oxalic acid remaining was titrated with potassium permanganate. As the amounts used in the deeper submarine measurements were very small, it was necessary to titrate with the greatest care, and an allowance was made colorimetrically for any excess of permanganate added in the final drop.

A comparison between tubes of quartz and of Monax resistance glass in air showed that the reaction was only 1.14 times greater in the quartz than in the glass.

The method must be very interesting to oceanographers, but it is not clear from the paper whether the results are so reliable and the procedure so easy that the method could be recommended for routine work. With regard to measurements actually carried out in sea water we may quote the following summary given by the authors:

"1. The uranyl oxalate method of daylight photometry has been used to determine the absorption coefficient of water at depths down to 40 metres at International Hydrographic Station E 1, about 10 miles S.W. of the Eddystone in the English Channel off Plymouth. Using quartz tubes on seven days from July to November inclusive the absorption coefficient varied 0.095 for 5 m. on July 23rd to 0.217 for 15 m. on August 9th; no seasonal variation was shown. The interpretation of the coefficients has been discussed in the paper dealing with the photo-electric measurements," (which has been under review in "Journal du Conseil", Vol. IV, No. 1, p. 108 and No. 3, p. 343).

"2. The ratio of the photo-chemically determined coefficients (using quartz tubes) to the photo-electrically determined values (obtained with potassium vacuum and gas-filled glass cells) varied from 1.02 to 1.46 or to 1.37, omitting a probably erroneous value from a series. Using glass tubes the same ratio was 1.10. The ratios are based upon mean values for the various depth series." MARTIN KNUDSEN.

H. BRANDES. Ueber die Verwendung des Wolfschen Ablaufkolorimeters für die Bestimmung der Wasserstoffionenkonzentration des Wassers bei Anwendung von Phenolphthalein. Ann. d. Hydrogr. usw. LVIII. Jahrg. (1930). Heft IV. Berlin, 1930.

Um die Genauigkeit bei der Bestimmung der Wasserstoffionen-Konzentration zu erhöhen, benutzt der Verfasser das Wolfsche Ablaufkolorimeter, also ein Verfahren, bei dem durch Veränderung der Schichthöhe einer Standardfarblösung Farbgleichheit mit der unbekannten Lösung hergestellt wird und dann aus dem Verhältnis der beiden Schichthöhen nach dem Beerschen Gesetz oder auf Grund einer Eichung die Konzentration der unbekannten Lösung berechnet wird. Im vorliegenden Falle wird der eine Zylinder mit dem zu untersuchenden Wasser gefüllt, der andere mit Pufferlösung von sicher grösserem *pH* und beide mit derselben Menge Indicator (Phenolphthalein) versetzt. Dann wird die Pufferlösung abgelassen, bis Farbgleichheit erreicht ist. Das Kolorimeter wird mit Pufferlösungen (Borax-Borsäure nach Palitzsch) von verschiedenem *pH* geeicht und gestattet die Bestimmung des *pH* von Meerwasser mit einer Genauigkeit von einer Einheit der zweiten Dezimale, wenn man das Mittel aus mehreren Einstellungen nimmt. Allerdings ist auch eine grössere Wassermenge nötig als bei anderen Verfahren und das Anwendungsbereich ist auf solche Wasserarten beschränkt, bei denen ein einfarbiger Indicator (wohl hauptsächlich Phenolphthalein) benutzt werden kann. Es ist deshalb besonders für Untersuchungen in der Nordsee geeignet. H. WATTENBERG.

KURT BUCH. Die *pH*-Bestimmung des Meerwassers. Studien über Eigenschaften und Gebrauch einiger hierfür geeigneten Farbenindicatoren. Merentutkimuslaitoksen Julkaisu Havsforskningsinstitutets Skrift. N:o 53. Helsinki, 1928.

The extension of work on the *H*-ion concentration of the sea has necessitated methods which will be applicable to seas in which the range in *pH* value is greater and the fluctuations in salinity more considerable than in the open sea. The author of this paper has worked out suitable methods for use in the Baltic.

There is unfortunately no single dyestuff which covers the whole range of *pH* values met with in the Baltic as satisfactorily as cresol red does for the open sea. Phenol red is fairly suitable and the author, by using suitable mixtures of this dye with brom thymol blue has been able to improve its utility in the acid range (6.8—7.9). The alkaline range (7.75—8.30) needs no admixture. The buffer tubes are considerably larger than are commonly used and the interval between successive tubes greater (0.15) than is necessary with cresol red (0.05).

A method has also been devised for the measurement of the *pH* value of samples of sea water either over- or under-saturated with carbon dioxide. Generally it is only samples from deep water which require such precautions.

In addition to discussing the suitability of other methods and other indicators, the author has made a thorough investigation of the keeping power and salt error of phenol red. In alcoholic or aqueous solution, phenol red does not keep well, there being an appreciable change in a few days and a 50 per cent. change in ten days. This change is not simply fading, and in the acid range there is actually an increase of colour caused by the formation of another dyestuff which does not act as an indicator though it has much the same tint. If, however, the salt of the indicator is formed by dissolving in water and adding the requisite amount of caustic soda, the dye keeps unchanged for months. For use at sea, where the tubes cannot be kept under ideal conditions, it is advisable to change them every month.

The salt error which is a factor of considerable importance in the Baltic has been worked out, and curves are given showing this for phenol red as well as for α-napthol phthalein using different buffers. His results differ from those of SÖRENSEN and PALITZSCH, but as BUCH took precautions to avoid contamination by the carbon dioxide of the air while SÖRENSEN and PALITZSCH did not, his results should be accepted. The spectrophotometric method he used as compared with the colorimetric one of SÖRENSEN and PALITZSCH does not explain the discrepancy since the spectrophotometric method gives similar results to the colorimetric method. Working from the theoretical point of view, he is able to formulate the relationship between salt error and ionisation and the results are in agreement with the practical findings except at the limits of the curves.

The methods should prove of use for other seas than the Baltic and should be applicable to inshore and estuarine conditions. A. P. O.

J. F. Reith. Der Jodgehalt von Meerwasser. Recueil des Trav. Chim. des Pays-Bas. T. 49, no. 1. Amsterdam 1930.

Reith finds that the determination of iodine in sea-water presents some difficulties on account of the presence of other salts, especially of bromides. The great differences in the iodine content of sea-water fouod by previous investigators may only be explained by the imperfect methods they used and not by other factors such as the assimilation of iodine by algae, the liberation of iodine from dying algae and the evaporation of iodine from the sea.

The two chief methods (Winkler, Z. Anal. Ch., 29, 68, 1916 and v. Fellenberg, Biochem. Z., 139, 404, 408, 1923) are discussed. Winkler reduces the iodates in 1 liter of sea-water by adding As_2O_3 and HCl, followed by an excess of $NaNO_2$ and the iodine liberated is thrice shaken out with 50 lcc. CCl_4. The iodine is then concentrated and the colour of the remaining solution compared with standard solutions prepared by shaking out known quantities of iodine from an artificial sea-water. v. Fellenberg extracts the iodides with alcohol after reduction of the iodates by means of $NaHSO_4$, concentrates the iodine by a repetition of this extraction and finally determines it by either a colorimetric or titrimetric method. The method of Winkler always yields much higher results but has some disadvantages in that it does not allow the determination of organic iodine; reducing substances may be present which are able to bind the liberated iodine and only 46 per cent. of the original iodine is present in the last 0.5 cc of carbon tetrachloride. The author found that bromides disturb both the colorimetric and titrimetric determination used by v. Fellenberg. He therefore developed a new method which yields satisfactory results. Five hundred cc. sea-water are filtered through cotton and 100 mgm. $NaHSO_3$ and 5 cc. iodine free 4 normal HCl are added to reduce the iodate. After a few minutes the sample is made alkaline by adding 10 cc. of a saturated solution of potash and boiled for about 10 minutes. Calcium and magnesium carbonate are removed by filtration through paper in a Büchner funnel and washed with a little hot water containing K_2CO_3. The filtrates are evaporated to dryness and the residue triturated with 20 and then 10 cc. alcohol, four times in all. The extracts are decanted each time into a platinum dish. After the fourth extraction some saturated potash solution is added and the alcohol quantitatively poured off. The extracts are evaporated to dryness after 1 cc. of the potash solution has been added, are lightly ignited and again extracted four times with 2 cc. alcohol. This extract is evaporated and the dry residue dissolved in 4 cc. water. The titration is performed according to the bromine-acetic acid method: (for details refer to Rec. Trav. 48, 346, 1929 and Biochem. Z., 216, Heft 3—6, 1930). 0.1 cc. glacial acetic acid, 3 drops of saturated bromine water and water (final volume 2 cc.) are added, the excess of bromine removed by boiling and the iodic acid titrated according to Winkler with 0.001 normal thiosulphate. Titration according to a bromine-sulphuric acid method did not yield concordant results. Practically no alcohol insoluble organic iodine was found (0.8 gamma per liter). The quantity bound to plankton was also very small (0.4 gamma per liter). The bromine content of two samples

of the purified residue determined before titration was 4.0 mgm. and 4.5 mgm. respectively. The results yielded by the new method were in good agreement with those yielded by WINKLER's method with the same samples. The author believes it very improbable that alcohol soluble organic iodine is present in sea-water although his method does not allow any definite conclusions. In a table the results of his investigations on 11 samples of water from different seas (North Sea, Atlantic Ocean, Mediterranean, Red Sea, and Indian Ocean) are compared showing that there are no great differences in their iodine content [43.4 (North Sea) — 69.5 gamma (Red Sea)]. There is no appreciable difference between the iodine content of water from a depth of 900 m. and that of the surface.

KARL CLOSS.

THOMAS G. THOMPSON, ROBERT C. MILLER, GEORGE H. HITCHINGS and SELDON P. TODD. Studies of the Sea Water near the Puget Sound Biological Station during the Summer of 1927. Pub. Puget Sound Biol. Station. Vol. 7, pp. 65—99. Washington 1929.

Spezieller Gegenstand der Untersuchung war der Einfluss der Gezeitenströmungen auf den hydrographischen und chemischen Zustand im Wasser in der Umgegend der biologischen Station im Puget Sound, gelegen im Staate Washington. Hier wurde im August 1927 während eines Gezeitencyclus von 25 Stunden ein Mal in der Stunde eine Wasserprobe entnommen und analysiert. Ausserdem wurden im Juli und August auf mehreren Fahrten von gewissen in der benachbarten Wasserstrasse gelegenen Punkten Wasserproben von verschiedenen Tiefen entnommen. Bestimmt wurden $t°$, Cl. ‰, O_2, pH, CO_2-Gehalt. Ausserdem wurden Bestimmungen des Pufferwertes ausgeführt, womit der pH-Wert bezeichnet wurde, den man erhält, wenn man der Wasserprobe eine bestimmte Menge HCl (25 cm^3 0.02266 n. HCl pro 200 cm^3 Wasser) zufügt, sowie des weiteren Bestimmungen der »beweglichen« Kohlensäure, womit die Verf. die Kohlendioxydmenge bezeichnen, die aus einer gegebenen Wassermenge bei Durchleitung von CO_2-freier Luft ausgetrieben werden kann. Schliesslich wurde auch eine Bestimmung des Jod-Verbrauchs (Titration des Wassers mit 0.001 n. Jodlösung) eingeführt.

Die in Tabellen und Diagrammen zusammengestellten Resultate ergeben, dass in dem Wasser bei der biologischen Station bei im allgemeinen nur geringer Beeinflussung durch das Süsswasser des Fraser River eine deutliche Beziehung des Chlorgehaltes der Jodzahl und in gewissem Masse der Temperatur und des pH-Wertes zu den Gezeitenschwankungen besteht. Das hauptsächlich durch Spieden Channel einströmende Flutwasser begegnet dem vor Strait of Georgia kommenden Ebbenwasser, welch letztes sich durch höhere Temperatur, niedrigeren Salzgehalt, höhere Alkalinität und niedrigeren CO_2-Gehalt vom ersten unterscheidet. Ausserdem ist das Flutwasser blau während das Ebbenwasser, wahrscheinlich durch Diatomaceen, grün gefärbt ist. Die verschiedene Dichte beider Wasser verhindert Durchmischung und bringt eine deutlich erkennbare Demarkationslinie zwischen blauem und grünem Wasser zustande.

Die Verf. diskutieren sodann die gegenseitigen Beziehungen von

pH, CO_2 und Sauerstoff und finden, dass O_2 und CO_2 zwar die zu erwartende Reciprocität aufweisen, dass aber pH sich in mehreren Fällen in gerade entgegensetzter Richtung hin ändert als theoretisch aus den O_2- und CO_2-Änderungen zu erwarten wäre. Dieser Befund, gestützt durch ähnliche Befunde anderer Forscher, führt die Verf. zum Schlusse, dass die in Laboratoriumsuntersuchungen von Mc. Clendon, Buch u. a. gefundenen Relationen zwischen den Kohlensäurekonstituenten nicht für die Verhältnisse in der See *in situ* anwendbar sind, und zwar aus dem Grunde nicht, weil im Meere äusserst selten, vielleicht überhaupt nie Gleichgewicht zwischen ihnen herrscht. Als Beweis hierfür wird ein Befund von Johnston angeführt, der zeigt, dass wenigstens eine der Reaktionen, die durch Veränderung des CO_2-Gehaltes eintreten, eine Zeitreaktion ist. Indessen ist den Verf. offenbar nicht die verdienstvolle Arbeit von Carl Faurholt[1]) bekannt, welche die hierhergehörenden Reaktionsserien eingehend gerade in bezug auf Geschwindigkeit studiert und die Frage vollkommen klargelegt hat. Die einzige Zeitreaktion ist die Bildung von HCO'_3 aus CO_2, die auf zwei Wegen geschehen kann. 1) $CO_2 + H_2O = H_2CO_3$ worauf sich H_2CO_3 unmessbar schnell ionisiert. 2) $OH + CO_2 = HCO'_3$. Erstere findet bei saurer, letztere bei alkalischer Reaktion statt. Die Umwandlung geht am langsamsten bei pH = 8 vor sich, und wird dann bei 0° in 700 und bei 18° in 80 Sekunden zu 90 % vollendet.

Bei der zur Zeit der Untersuchungen im Puget Sound herrschenden Temperaturlage von 10° bis 12° können also bei Gleichgewichtsstörungen die Einstellungen der neuen Gleichgewichte nicht mehr als einige Minuten beansprucht haben. Wenn man bedenkt, wie unendlich geringe Mengen CO_2 z. B. die Phytoplanktonorganismen bei der Photosynthesis in der Zeiteinheit dem umgebenden Wasser entziehen, werden wir wohl zur Annahme gezwungen, dass wenigstens in offenen Meeresgebieten stets praktisch vollständiges Gleichgewicht zwischen den direkt mit einander reagierenden Kohlensäurekonstituenten herrscht. Die eventuelle mangelhafte Übereinstimmung der Befunde mit der Theorie beruht nur auf unserer Unkenntnis der letzten. Definitive Erklärungen der Vorgänge können erst erbracht werden, wenn die apparenten Dissoziationskonstanten der Kohlensäure im Meerwasser festgestellt werden. Grundsätzlich müssen künftighin die Untersuchungen auf Feststellung von Konzentrationen *in situ* wie pH und die CO_2-Tension (proportional der freien gelösten Kohlensäure) gegründet werden. Bestimmungsmethoden, wie die der »beweglichen« Kohlensäure, können in dieser Hinsicht nichts leisten, wogegen die Totalkohlensäure und Titrationsalkalinität ihren Wert für die Charakterisierung des Wassers beibehalten.

Kurt Buch.

Marie V. Lebour. The Planktonic Diatoms of Northern Seas. — Ray Society. London 1930, IX + 244 pp. with many figures in the text and 4 plates.

A few years ago Dr. Marie Lebour published an account on "the Dinoflagellates of northern Seas", and the present publication on the plank-

[1]) Carl Faurholt: Studier over Kuldioxyd og Kulsyre og over Karbaminater og Karbonater. Dissert. Kopenhagen. Kandrup & Wunsch 1924. S. 59—61.

tonic diatoms of the same seas is to be considered as a companion to this useful book. It contains descriptions and figures of practically all the diatoms found in the plankton of northern seas; by "Northern Seas" the author means the seas from the Murman and the Arctic Seas north of Iceland to the English Channel and the Bay of Biscay in the south, and from the innermost Baltic in the east to the Atlantic west of Ireland and south of Iceland in the west.

Before entering upon the special treatment of the species and genera the book gives us a short, but clear and good, survey of the diatoms generally: their morphology, nutrition, reproduction, habit etc., parasites and symbiotic associations, and classification.

It has been necessary for the author to create a number of new families, while the genera and species were nearly all known before. The classification is, on the whole, a very natural one, although in a few places the reviewer would prefer another; thus it seems to me to be rather artificial to separate *Bacteriastrum* so far from *Chætoceras*; the author knows quite well, and indeed mentions the fact, that the two genera are usually placed together, the difference between them being only that *Bacteriastrum* has many planes of symmetry, while *Chætoceras* has only two. I should also prefer to keep *Corethron* close to *Skeletonema* and *Stephanopyxis*, and not put the *Leptocylindraceæ* in between them. But these differences of opinion are of slight importance.

The descriptions of the species are clear and on the whole very happy. It has been a rather difficult task to get a definite understanding of the species of several of the larger genera. This holds good especially for the genus *Coscinodiscus*, of which we here find the first thorough treatment of the planktonic forms[1]). We had the much earlier, extensive revision by Rattray which considered mostly forms from bottom deposits and many fossil ones and which was based solely upon the structure of the valves; later on workers on phytoplankton have contributed to the knowledge of the planktonic forms, but have not dealt with all the forms. Now Dr. Lebour has performed the dificult task of bringing the many additions together into one treatise and she seems to have had a happy hand for this work.

Also the treatment of the genus *Thalassiosira* contains several new things, while in the genera *Rhizosolenia* and *Bacteriastrum* she has followed the recent revisions by Pavillard and others.

As to the largest genus, *Chætoceras*, she has followed the conception of the species and their groups as given by H. H. Gran and the reviewer, and has added several new forms described by Mangin and Meunier without making much criticism of their arrangement in groups, and I feel that some of Meunier's species at least ought to be considered more critically than the author has done.

The pennate Diatoms, which play a much less important rôle in the plankton, are only shortly dealt with, but quite sufficiently.

The printing, etc., is excellent, as is the case with all the publications issued by the Ray Society, and workers on the plankton of the northern seas should be grateful for this fine work, which fulfills a want, as Gran's paper in "Nordisches Plankton" has become out of date. C. H. Ostenfeld.

[1]) It is a pity that the author has not seen Hustedt's treatment in his new work on the Diatoms of Germany etc.

W. C. Smith. A Study of the Manx Herring Shoals during the Period 1923—1928. Report for 1928 on the Lancashire Sea-Fisheries Laboratory. No. XXXVII. Liverpool, 1929.

Biometric and age data obtained from bi-weekly samples of herrings from commercial landings, supplemented by close personal observation of the landings themselves, form the raw material for Mr. Smith's studies of the Manx herring shoals. In the month of May shoals of herrings in their third and fourth years of life, with smaller quantities of fifth-year fish, begin to move into Manx inshore waters; and the numbers increase weekly until the end of July when the concentration is usually completed. A migration offshore then takes place to the spawning area which is situated, presumably, somewhere off the Calf of Man. Older fish, of five years and upwards, do not appear in Manx waters until the middle of August, when they are almost exclusively in "full" condition, with little intestinal fat. They are taken on the Calf of Man offshore ground until the middle of September, and begin to spawn about the first week of that month. These older fish do not move into the inshore area.

Mr. Smith infers that the inshore fish are recruit spawners assembling for their first spawning which will take place off the Calf of Man in the autumn, and he advances evidence to show that the first spawning occurs rather later in the season than subsequent ones. In his opinion the Manx herring first shoals for spawning during its fourth year of life in the majority of cases, although many individuals join the spawning shoals one year earlier, while a few may have reached their fifth year before gonad development begins. Certainly at the end of the fifth year practically all Manx herrings have spawned at least once.

The conclusions reached regarding the growth of the Manx herring, as compared with that in other areas, are rather less convincing. In the absence of contemporary data on the length of the fishes at the formation of the first winter ring on the scales, observed differences in total length between Manx herrings and those of a similar age from the North Sea, English Channel, Cardigan Bay and other districts are not easily interpreted in terms of relative growth-rates. Thus, although it is probably true that the herrings which live nearest to the open Atlantic are enjoying the most favourable conditions for growth, and that Manx fish, after spawning, migrate south to the Atlantic, the evidence offered in this instance is not in itself entirely conclusive. The same may be said concerning the reason why Manx herrings caught offshore are slightly larger than those of the same age taken inshore. Comparisons of growth between fishes of the same age-group must take fully into account the absolute size at the end of each annual growth increment, including the first.

Mr. Smith's contribution is a valuable one in that it gives assurance that in Isle of Man, as in other parts of British waters, continuous and detailed study of the local herring fisheries is being maintained.

E. F.

Alf Dannevig. The propagation of our common fishes during the cold winter 1924. Investigations on the Norwegian Skagerrack coast. Rep. on Norw. Fish. and Mar. Invest. Vol. III, No. 10. Bergen 1930.

Die vorliegenden Untersuchungen von Dannevig beziehen sich auf die norwegischen Küstengewässer des Skagerrak, und zwar bei Langesund, Arendal, Kristiansand und im Trysfjord. Innerhalb dieser Gebiete sind wiederum verschiedene Unterstationen vorhanden, die sich im allgemeinen vom Innern der Fjorde bezw. des Schärengürtels nach der offenen See zu aneinanderreihen.

Nach einer Besprechung der Untersuchungsmethoden und -geräte wird eine Charakteristik der Gewässer an der norwegischen Skagerrak-Küste gegeben und das in den verschiedenen Teilgebieten gesammelte Material im Einzelnen aufgeführt. Im Januar 1924 lagen die Oberflächentemperaturen bis zu 10 m Tiefe herab unter 0° C., aber in den Bodenschichten waren dann noch immer über 6° C. Bis zum April näherte sich die Oberflächentemperatur immer mehr dem Nullpunkt. Anfang Mai stieg sie bis + 5°. In 50 m Tiefe wurde am 29. Januar eine Temperatur 5,8° gemessen.

Die Monate März und April sind in den Gewässern von Arendal gewöhnlich von grosser Bedeutung für das Laichen und für den Fang von Kabeljau. Die Spärlichkeit von Kabeljaueiern und -larven in der letzten Märzhälfte und im April 1924 wird auf die niedrige Temperatur zurückgeführt. Die demgegenüber verhältnismässig hohe Eierzahl Mitte März soll durch die hohe Temperatur in den Bodenschichten verursacht sein, die Vermehrung in den letzten Apriltagen wiederum durch die steigenden Oberflächentemperaturen. Dannevig ist der Ansicht, dass die ersten Kabeljaueier von dem Ablaichen in mittleren Tiefen stammen, die späteren von dem in den Küstengewässern.

In den Fjorden liegen die Dinge anders. Das kalte Seewasser macht sich nur in den offenen Fjorden bemerkbar; in den mehr geschlossenen bleibt das Wasser während des Winters verhältnismässig warm, in tiefen Becken ist die Temperatur ziemlich konstant. Im Frierfjord und bei Kristiansand waren die Kabeljaueier zu einer Zeit zahlreich, zu der bei Arendal ein Minimum zu finden war. Es konnte überall festgestellt werden, dass in den Fjorden grosse Mengen von Kabeljaueiern (Schellfischeier waren in der Minderzahl) vorhanden waren, während sie ausserhalb nur in geringer Zahl anzutreffen waren.

Es werden dann weiter die 1924 gewonnenen Ergebnisse mit denen vom Jahre 1917 und denjenigen Dahls bei Risör 1905 verglichen. 1905 fiel das Maximum für Kabeljaularven in die letzten Tage des März, 1917 in die letzten Tage des April und 1924 Mitte Mai. 1905 war ein milder Winter, 1917 und 1924 waren kalte Winter. Dannevig glaubt aus dem Vergleich der drei Jahre die Schlussfolgerung ziehen zu können, dass es für den Ausfall der Kabeljaubrut günstig ist, wenn die beginnende Erwärmung des Oberflächenwassers etwas hinter die Hochzeit des Laichens fällt.

In den seichten Gewässern werden nach dem Einsetzen der Eisdrift keine erwachsenen Fische angetroffen, in den tieferen werden jedoch grosse Fänge gemacht. Dannevig stellte fest, dass die kritische Temperatur für den Kabeljau nahe bei — 1° C. liegt.

Der Verfasser bezeichnet es als unmöglich, die näheren Zusammenhänge zwischen einem strengen Winter und der Verbreitung der Fische und dem Ausfall der Fischerei aus den Beobachtungen weniger Jahre zu klären. Er macht aber auf einige wichtige Punkte aufmerksam, die ihm einer genaueren Untersuchung wert erscheinen. Eine sehr strenge Kälte im Winter kühlt das Oberflächenwasser des Skagerraks auf unter — 1° ab. Wenn dieses sehr kalte Wasser gegen die Küste gedrängt wird, wirkt es auf einen grossen Teil der Fische schädigend ein, besonders aber auf jugendliche Individuen. Die geschlechtsreifen Fische scheinen sich in Wasser mit höherer Temperatur zurückzuziehen. Die oft unter solchen Umständen tot aufgefundenen Fische sind *Labrus rupestris*, *Gobius niger*, *Gadus pollachius*, *G. morrhua* und *Conger vulgaris*.

Wenn die strenge Kälte längere Zeit anhält, kühlen auch die tieferen Schichten ab, sodass die Temperatur für das Laichen von Wittling und Schellfisch ungünstig wird, und auch der Kabeljau wird sich nach den mittleren Tiefen hin verziehen. Da eine Kälteperiode zu Beginn des Jahres das Laichgeschäft hinausschiebt, wird sich ein solches Witterungsverhalten günstig auf die Brut auswirken. Ist aber die Hochzeit des Laichens schon erreicht, wenn die Kälteperiode einsetzt, so wirkt dieser Umstand ungünstig auf die Brut ein.

Diese Verhältnisse gelten für die Küstengewässer. In den mehr abgeschlossenen Fjorden beeinflusst die Lufttemperatur nicht die Temperatur der tieferen Wasserschichten. Hier trifft man das Maximum der Kabeljaularven dann an, wenn die Oberflächentemperatur über diejenige der darunterliegenden Schichten zu steigen beginnt. Der Einfluss eines sehr kalten Winters zeigt also an der offenen Küste und in den Fjorden ganz verschiedene Auswirkungen auf die Fortpflanzung der Fische.

W. Schnakenbeck.

Aage J. C. Jensen. An Investigation of the Stock of Plaice in the Southern Horns Reef Area in the Years 1925 and 1927. Medd. fra Komm. for Havundersøgelser. Serie Fiskeri. Bd. VIII, Nr. 6. København, 1928.

Die Arbeit behandelt eingehend die Ergebnisse von Forschungsfahrten im Frühjahr und Herbst 1925 und im Herbst 1927 in dem Gebiet südlich von Hornsriff, nördlich des 55. Parallelkreises, von der 10 m-Linie bis zur Grenze der Verbreitung dichter Jungschollenschwärme.

Die Untersuchungen von 1925 geben willkommene Gelegenheit, Verteilung und Grösse des Bestandes zu verschiedenen Jahreszeiten desselben Jahres zu vergleichen. Wie im ganzen nordfriesischen Gebiet, so finden sich auch hier im Frühjahr reiche Schollenbestände nur innerhalb der 20 m-Linie, während sie im Herbst bis weit über die 40 m-Linie hinaus verbreitet sind. Eine Berechnung zeigt, dass der Herbstbestand in fast allen Grössen- und Altersgruppen grösser ist als der Frühjahrsbestand. Mit Recht nimmt der Verfasser an, dass dies nur eine lokale Erscheinung ist, die durch grössere Dichte der Schollenansammlungen im Frühjahr weiter südlich in der Deutschen Bucht ausgeglichen wird. (Eine ähnliche Berechnung ergibt für das deutsche Material aus diesem Gebiet, dass Frühjahrs- und Herbstbestand — allerdings in aufeinanderfolgenden Jahren, 1924 und

1925 — gleich gross sind). — Der Bestand war in dem Untersuchungsgebiet 1922, 1925 und 1927 im Frühjahr bzw. Herbst grösser als in den Vorkriegsjahren, in denen vergleichbare Untersuchungen gemacht sind, 1903, 1904 und 1907. Die älteren Jahresklassen spielten 1925 und 1927 eine bedeutend grössere Rolle als 1922, wo ein grosser Teil des Bestandes der 0- und 1-Gruppe angehörte. Da sich aber gerade die jüngsten Gruppen zu einem wesentlichen Teil innerhalb der 10 m-Linie aufhalten und im Untersuchungsgebiet noch spärlich sind, so schliesst der Verfasser aus der Tatsache, dass die Zahl der Schollen im Stundenfang 1922 und 1925 etwa gleich war, dass der Gesamtbestand 1922 grösser gewesen sein muss als 1925 oder 1927. In Übereinstimmung mit den englischen Forschern findet Jensen, dass die einzelnen Altersgruppen 1925 ihr Dichtezentrum in grösserem Küstenabstand haben als 1922. Ihre weiter Ausbreitung seewärts ist die Folge des in der Zwischenzeit verbesserten Wachstums.

Ausführlich werden sodann die Unterschiede in der Stärke der einzelnen Jahresklassen besprochen, wie sie sich durch den Vergleich der Häufigkeit gleicher Altersgruppen in verschiedenen Jahren ergeben. Jensen berücksichtigt den Fang pro Stunde, benutzt also absolute Zahlen, nicht den Anteil der Altersgruppen am Bestande. Auf diese Weise erzielt er sehr brauchbare Resultate. Er weist aber darauf hin, dass die Art und Intensität der Befischung die Häufigkeit der älteren Gruppen mitbestimmt, und dass man daher bei der Benutzung der gewonnenen Werte etwaigen Veränderungen dieser Faktoren Rechnung tragen muss. Dieser Forderung versucht er gerecht zu werden. Das Endergebnis ist dann die Einordnung der Jahrgänge 1918 bis 1926 nach ihrer Stärke in 6 verschiedene Stufen. 1922 ist der beste, 1924 (26?) der schlechteste Jahrgang, 1920 und 25 sind gut, es folgen in etwa gleicher Stärke 1919, 1921, 1923. Ein Vergleich mit den Ergebnissen anderer Autoren zeigt, dass der Ausfall mancher Jahrgänge in der ganzen südlichen Nordsee gleich, der anderer aber regional verschieden ist.

Die Wachstumsgeschwindigkeit hat im allgemeinen seit 1922 zugenommen. Der sehr dichte Jahrgang 1922 aber steht an Durchschnittslänge anderen Jahresklassen in gleichem Alter nach.

Infolge der veränderten Alterszusammensetzung und der gesteigerten Wachstumsgeschwindigkeit ist die wirtschaftliche Ertragsfähigkeit des Bestandes bedeutend gestiegen. Da eine gleichartige Entwicklung auch auf den anderen von dänischen Kuttern befischten Gründen, z. B. der Deutschen Bucht vor sich ging, so ist es verständlich, dass der Fangertrag dieser Fischerei sich seit 1922 bedeutend gesteigert hat, wozu die Verbesserung der Absatzverhältnisse noch beitrugen.

Jensen stellt fest, dass eine auffallende negative Korrelation zwischen der mittleren Länge der Altersgruppen an den einzelnen Stationen und der Gesamtmenge der dort gefangenen Schollen besteht. Er erklärt das damit, dass die grossen Schwärme während der sommerlichen Weideperiode die Tendenz haben zusammenzubleiben, und dass daher die Individuen derselben infolge der Nahrungskonkurrenz im Wachstum gehemmt sind. Ein derartiger Zusammenhang lässt sich anscheinend nur auf einem kleinen Gebiet festellen, denn in dem deutschen Material von 1925, dessen Proben über ein weites Gebiet verstreut gesammelt sind, ist nichts davon zu be-

merken. Grössere Unterschiede in den Ernährungsbedingungen in verschiedenen Gebietsteilen machen vielleicht die Beziehung unkenntlich.

Nachdem noch die beobachteten Geschlechtsverhältnisse besprochen sind, entwickelt JENSEN ein zusammenhängendes Bild der Bestandsveränderungen nach dem Kriege. Es zeigt sich, dass die Entwicklung der Dinge auf allen Jungfischgründen der südlichen Nordsee sehr ähnlich verlief. Die Wachstumsverhältnisse der Schollen auf dem Schnitte Leman-Haaks zeigen allerdings einige Besonderheiten, die JENSEN auf den Einfluss des Bestandes der offenen Nordsee zurückführt. Besonderes Interesse verdienen die Darstellungen über die Wechselwirkungen zwischen den Jungbeständen und dem Bestand der zentralen Gründe. Ein bemerkenswerter Zug der ersten Nachkriegsjahre ist die geringe Menge der von den englischen Dampfern erbeuteten Schollen der Marktsorte klein. Diese Erscheinung wurde von GARSTANG durch die Annahme erklärt, dass die kleinen Schollen durch die Nahrungskonkurrenz des »angehäuften Bestandes« von den tieferen Gründen ferngehalten und an der Küste zusammengedrängt wurden, wo ihre Zahl durch Nahrungsmangel dezimiert wurde. JENSEN stellt fest, dass eine solche Zusammendrängung im Hornsriffgebiet nicht stattgefunden hat und findet ausreichende Erklärung für den anfänglichen Mangel und späteren Überfluss an kleinen Schollen in den Veränderungen der Wachstumsgeschwindigkeit, der Lage der Fangplätze und der Stärke der einzelnen Jahrgänge, Hierzu darf bemerkt werden, dass die Menge der grossen Schollen in der Deutschen Bucht nach den Untersuchungen des »Poseidon« von 1919 und 1920 nicht gross genug war, um das beobachtete Fehlen kleiner Schollen auf den Gründen ohne weiteres durch Nahrungskonkurrenz des angehäuften Bestandes zu erklären. Es ist daher sehr wahrscheinlich, dass die Anschauungen des Verfassers für das Gebiet der Deutschen Bucht zutreffen.

BÜCKMANN.

AAGE J. C. JENSEN. On the influence of the size of the stock of cod upon the yield of the herring fishery in the Kattegat, Belt Sea and western part of the Baltic, and some other causes of variations in the cod and herring fisheries. Meddelelser fra Kommissionen for Havundersøgelser. Serie Fiskeri, Bd. VIII, Nr. 8. København, 1929.

Die vorliegende Arbeit bildet einen Beitrag zu der Frage nach den Ursachen der Fluktuationen in den Ausbeuten der verschiedenen Fischereien. Der Verfasser sucht zu beweisen, dass in der Ostsee einschliesslich dem Kattegat die Erträge der Dorsch- und Heringsfischerei in bestimmter Beziehung zu einander stehen, da der Dorsch sich in diesen Gewässern vielfach von jungen, 1- und 2-jährigen Heringen nährt. Je nach den verwendeten Fanggeräten sollen die Erträge der Heringsfischerei bei grossen Dorschbeständen nach ein bis drei Jahren sinken, und in demselben Zeitraume steigen, wenn weniger Dorsche vorhanden sind. Die Bestätigung seiner Annahme findet JENSEN in der Statistik, die er für die Zeitspanne von 1909—1927 analysiert, um festzustellen, welchen biologischen und wirtschaftlichen Einflüssen die Erträge beider Fischereien unterworfen sind, und wieweit sie als ein Ausdruck von Fluktuationen innerhalb der Fisch-

bestände angesehen werden können. Da eine steigende Intensität des Dorschfanges, eine sinkende des Heringsfanges vorhanden ist, verlaufen die Kurven beider Fischereien im entgegengesetzten Sinne. Erst wenn man diesen Faktor ausschaltet und Normalausbeuten und die jährlichen Abweichungen von diesen berechnet, erhält man vergleichbare Werte, die zur Bestimmung von Korrelationskoeffizienten dienen können. JENSEN behandelt getrennt die Fischerei mit Stellnetzen (die vorzugsweise junge Heringe liefert) und Bundgarnen auf der einen Seite, und die Treibnetzfischerei (welche die ältesten Heringe fängt) andererseits, und findet in Kattegat, Sund, Beltsee und westlicher Ostsee sehr hohe negative Korrelationskoeffizienten zwischen der Ausbeute des Dorschfanges eines jeden Jahres und der erstgenannten Art der Heringsfischerei im nächsten und übernächsten Jahre, während die Korrelation für die Treibnetzfischerei nach 2 und 3 Jahren eintritt. In der eigentlichen Ostsee dagegen fehlt eine derartige Beziehung. Seit 1927 allerdings heben sich die Erträge der Heringsficherei trotz gleichzeitiger grosser Dorschfänge, weshalb der Verfasser annimmt, dass nun einige gute Laichjahre die Grösse der Heringsbestände beeinflussen. Anscheinend hat dieser Faktor in der Periode vor 1927 einen Einfluss auf die Dorsch- und Heringsfischerei nicht gehabt, obwohl z. B. ein guter Heringsjahrgang in der Ostsee 3—4 Jahre lang in den Beständen überwiegen kann, also ebenso lange wie in der Nordsee, in der die Erneuerung der Bestände von ausschlaggebender Bedeutung für den Ausfall der Fischerei ist.

Zum Schlusse werden einige Angaben über die wahrscheinliche Ursache der Fluktuationen in den Dorschbeständen des untersuchten Gebietes gemacht. Es wird eine direkte Beziehung gefunden zwischen der Temperatur des Wassers am Boden des Kattegat (bei Schultz' Grund Feuerschiff) in den Monaten März bis Juni und dem Ausfall der Dorschfischerei 4 Jahre später, dergestalt, dass hohe Temperaturen die Entwicklung der Brut begünstigen. Könnten Einflüsse ähnlicher Art auch für andere Fische und andere Meeresteile nachgewiesen werden, so wäre das von grosser Bedeutung für die Ausgestaltung der Voraussagen über den Ausfall der Fischerei.

H. L.

JEAN LE GALL. Remarques et statistiques biologiques sur les Harengs de la Mer du Nord, de la Manche et de l'Atlantique. Revue des Travaux de l'Office des Pêches Maritimes. Tome II, Fasc. 4, Paris 1929.

This paper from the Marine Laboratory at Boulogne-sur-Mer by JEAN LE GALL and his colleagues is based on the material collected during 1928. Some 5000 Herrings were examined. The paper is divided into two main sections. The first section includes the results of an analysis of samples from the Dogger Bank and the Dyck-Sandettié-Ruytingen regions of the North Sea, from the Plymouth Bay region of the English Channel, and from the south coast of Brittany and the north coast of Ireland regions of the Atlantic. Details are given of the size and age, and in some instances of the maturity, vertebral counts and growth. A comparison with results obtained during 1927 from the same regions is also given in some cases. The material collected from the south coast of Ireland "Smalls grounds",

and the detailed analysis of the Dyck-Sandettié-Ruytingen region samples are held over for separate publications, so beyond giving the results of the analysis but little attempt has been made at a critical analysis of the samples.

Much of the material collected from the English Channel particularly that from the Normandy, Kent and Sussex coasts is dealt with in the second section of the paper "Statistiques biologiques et considerations sur la population harengière de la Manche orientale", which was presented to the Conseil International pour l'Exploration de la Mer in April 1929. This section gives a detailed analysis of samples from the eastern part of the English Channel. It is based mainly on samples collected during 1928, which are compared with the results obtained during 1926 and 1927. A critical analysis of the results suggests to the author that the Channel Herring are composed of two main groups. The first group constitutes those Herring inhabiting the region from Cape Gris-Nez to the mouth of the Somme and which he identifies with the "Southern North Sea type". The second group constitutes those Herring inhabiting the region from the mouth of the Somme to Cape Antifer, and also the English coasts of Kent and Sussex which he designates the "Channel type". This latter he envisages as arriving in the eastern Channel from more westerly grounds, the extent of the migration depending upon the extent of the movement of waters of 35 $^{0}/_{00}$ salinity, and suggests that a study of the water movements of the English Channel would enable a prediction to be made of the extent of the annual migration of Herring into the eastern Channel waters. The distinctions between the "Northern Sea type" and the "Channel type" appear to be significant and are based mainly on vertebral counts and total length averages for each age group. It will be interesting to see if a study of calculated growth from the scales supports these distinctions. The publication of the further papers, particularly those on the Dyck-Sandettié-Ruytingen Herring and on the Smalls Herring will be awaited with interest. E. Emrys Watkin.

Bjarni Sæmundsson. On the Age and Growth of the Coalfish (*Gadus virens* L.), the Norway Pout (*Gadus esmarki* Nilsson) and the Pout-assou (*Gadus poutassou* Risso) in Icelandic Waters. Meddelelser fra Komm. f. Havundersøgelser. Serie Fiskeri, Bd. VIII, No. 7, København, 1929.

In completion of his series of studies on the Gadoid fishes found in Iceland waters Sæmundsson, in the above paper, makes many new points relative to the biology of the hitherto little-studied species detailed in the above title. Of the three only the coalfish is of direct economic importance, a merit derived rather from the large size it attains than from the numbers in which it is caught. The author refers to this species as being common all round Iceland — and especially so in the warmer waters off the south and west coasts. As regards the larger fish this is probably more true of certain localities than of the area generally, as is also the case in British waters, where (e. g. in certain parts of the Firth of Clyde) coalfish occasionally form the major portion of the trawl catch, while occurring only spo-

radically in the general area. In the comprehensive trawling cruise of the "Explorer" (June 1925) in Iceland waters only 18 mature coalfish were captured, as compared with many thousands of other Gadoid species, so that to the trawlerman this species must, except perhaps in the spawning season, appear to be of the rarer sort. This is probably largely due to the pelagic life favoured by medium-sized coalfish (of, according to SÆMUNDSSON, ages 3 to 5 years). Few of these fish are even captured, and as the author hints, this period of virtual sanctuary in the life-history serves to protect the coalfish stock from undue depletion, of which he detects no sign. The youngest fish (up to 3 years of age) he states to be exceedingly numerous in inshore waters, and the Iceland fishermen capture them in the drag-seine, the drift-net, and the purse-seine. The tendency of the coalfish to lead a pelagic life apparently decreases after maturity is reached (at 5 or 6 years of age) but never entirely disappears, so that the gill-net adds to the toll taken by the long line and the trawl.

The author has found it a simple matter to determine the age of the coalfish from the particularly transparent scales. The Petersen method of age-determination alone suffices in the case of the youngest year classes, which do not overlap in their size-distribution. He finds that, as is the case with cod and haddock, growth is slower off the north and east than off the south and west coasts. The growth rate and maximum size attained by the coalfish in Norwegian waters is much exceeded in Iceland waters, yet nevertheless, as is the case with haddock, maturity is a year or two later in being attained in the latter. An explanation of this seeming paradox is worthy of being sought after.

With regard to the location of spawning grounds and the distribution of fry and young stages the coalfish resembles the cod and haddock. Spawning takes place a month or two earlier in the year, however, than in the case of the latter species. The food most commonly taken consists of herring, sand-eels and schizopods.

The small but exceedingly numerous Norway pout is taken little cognisance of by the fisherman since for the most part it slips through the trawl meshes, yet, as the author states, it is of vital importance in that it forms part of the food supply of larger fish species. It spawns at the same time and in the same area as the cod, but the resulting fry are less extensively distributed. SÆMUNDSSON examined 677 specimens, and the study of some 3000 specimens taken by the "Explorer" confirms practically all his conclusions. The species does not occur east of North Cape and only exceptionally east of Ingolfs, thus being confined to the south and west coasts. The male fish mostly mature at 2 years of age, but female fish are mostly one year later in reaching maturity, and in conformity with this fact live on the average one year longer than the males. The life of the species, however, is short, death, according to the author, apparently occurring after the second spawning. The maximum size attained is 25 cms. and the maximum age 5 years. The scales of this fish being deciduous the author made his age-determinations from the otoliths, and found that fish of age 3 were most numerous. Presumably the first and second year fish are to a larger extent pelagic, and so escape trawl capture in proportionate numbers. The probability that a pelagic mode of

life is followed even by the older fish is suggested by the fact that Sæmundsson found the chief food of the species to be *Calanus* and *Meganyctiphanes*. He suggests that sizes of 11, 16½, 19 and 21½ are reached at the end of years 1—4 respectively. From the "Explorer" material, which included a larger number of young fish than was available to the author, it would appear that these figures are approximately correct, though the reservations might be made that North Cape specimens fall 1—2 centimetres short of the average first year figure, and south coast specimens exceed that figure by a similar amount; and that, if a fine mesh covering be used on the trawl, the average size of the two year old fish drops from precisely 16.5 cms. to 15.8 cms. The length of the female fish exceeds that of the males of the same age by anything up to 10 per cent.

The third species dealt with — the poutassou — is stated to be a juvenile visitor to Iceland waters from more oceanic waters in the south. No previous investigations into the age and growth rate of this fish have been made. Sæmundsson examined 32 specimens, ranging in size from 18 to 35 cms., at depths of from 180 to 200 metres. The "Explorer" took in all 281 specimens, at depths of from 104 to 213 metres, ranging in size from 16 to 36 cms. Only five of these specimens were taken on the north coast, so that general agreement can be expressed with the author that the species is confined to the south-west and south coasts, with Ingolfs as the eastern limit. He regards the sizes attained at the end of years 1—3 to be 16, 21 and 25 cms. respectively. (In Table I, p. 36, under Age-group III, the figure 26.0 cms. is an erratum for 25.0 cms.). All the fish examined by him were immature. From a study of the otoliths it was found that the III-Group was the most common age-group, but that fish up to the age of five years also occurred. Like the Norway pout the poutassou is of little direct interest to the fisherman, but contributes to the food supply of larger fish such as the cod.

The seasonal movements of the coalfish, Norway pout and poutassou are also outlined in this paper, and the features of scale structure are, where possible, made use of for the determination of the time of onset and the duration of the growth season. It is of interest to note that the scales of the poutassou are devoid of obvious "winter rings". H. T.

R. Spärck. Preliminary Survey of the Results of Quantitative Bottom Investigations in Iceland and Faroe Waters, 1926—1927. Cons. Perm. Int. pour l'Explor. de la Mer. Rapp. et Proc.-Verb., Vol. LVII. Copenhague 1929.

During the cruises of the "Dana" in Faroese and Icelandic waters in the summers of 1926 and 1927, the Petersen and Knudsen bottom samplers were used to survey the benthic fauna. At the Faroes, 108 samples in all were taken, for the most part with the Petersen sampler and during the months of May and June. In Icelandic waters and especially in Faxe Bay, the total number of samples was 164, again mostly taken with the Petersen sampler. Dr. Spärck, by his analysis of these samples, has, so to speak, provided the rough sketch which precedes the desired picture of the fauna of the sea-bottom in these regions. It is therefore best that we should note

those features which he has most plainly outlined. At the Faroes, a *Modiola* epifauna is by far the most important item so far as the fisheries are concerned, the fauna of the level sea floor being either too poor, or the communities of too slight extent, to be of any considerable value as food for fishes. The *Modiola* epifauna covers large areas along the open coasts and in the sounds between the islands. It includes a number of organisms furnishing excellent food for cod, notably *Galatea nexa*, *Ophiopholis aculeata*, *Hyas* and annelids; so much so that in the northern part of the Faroe waters, a little distance from land (within an area lying from 2 to 10 miles out), there should be good conditions of growth for cod, whereas off the southern parts of the islands conditions must be regarded as far less favourable.

In Faxe Bay, Iceland, the situation is markedly different. In contrast with that of the Faroes, the clay and sand communities are here very important in their relationship to the fisheries. There is every reason to believe that the sand community in the south of Faxe Bay, dominated by *Mactra elliptica*, forms the main basis for the plaice fishery there. A shallower clay community in which *Macoma calcarea* predominates is also of considerable economic importance.

Dr. Spärck observes that all the communities in the Faroe and Iceland waters are poorer in species than the corresponding communities of north-western Europe. Such molluscs as *Cardium edule*, *Mya arenaria* and *Macoma baltica*, which are characteristic of the fauna in shallow and calm waters like the Zuyder Zee, the coastal waters of the German North Sea coast, and most Danish waters even into the Baltic, are entirely lacking in the communities of Iceland and the Faroes. Although a few arctic species may be said to be common, none save *Sternaspis fossor* are of dominant importance, so that there is no indication, even on the North Coast of Iceland, of truly arctic communities similar in character to those described from the Barents Sea and White Sea. One feature held in common with more northerly waters, however, is the scarcity of echinoderms, in contrast with what is found in the Kattegat and the North Sea.

This report, which is quite short and accompanied by full sample data on numbers and weight per 1 sq. m. of each species, should prove very useful as a preliminary to further investigations. E. F.

H. Thompson. General Features in the Biology of the Haddock (*Gadus aeglefinus* L.) in Icelandic Waters in the Period 1903—1926. Cons. Perm. Int. pour l'Explor. de la Mer. Rapp. et Proc.-Verb., Vol. LVII. Copenhague, 1929.

Besides Dr. Thompson, only two naturalists, Dr. B. Sæmundsson and Prof. Johs. Schmidt, have hitherto written on the subject of the Icelandic Haddock. Dr. Thompson, however, is the first to use the scales of this fish in estimating its past lengths at various stages.

On the basis of hydrographical conditions he divides the whole Icelandic plateau into 3 natural sub-areas: (a) the south and west, (b) the north and (c) the east coasts. This subdivision also corresponds very well with the different growth rates of the haddock in these waters. The growth is

most rapid on the south coast and slowest on the east, while the north coast is intermediate in this respect. According to growth rate there are two main types of Icelandic haddock, the south coast and the north coast types.

The scale measurements have received most careful and critical attention, and, as the material is very extensive, the results obtained by Dr. Thompson are particularly valuable, especially in regard to the migrations of the haddock.

It was found possible to obtain the mean size of an age group, say the III-group, both by measurement of the fish themselves and by scale measurement. The mean size found by the latter method is somewhat shorter than that found by direct measurement of the fish, a fact that can be explained in this way:— 1) In sampling the shoals of young haddock, the largest specimens are most liable to capture, while the small ones have a greater chance to escape and grow up. 2) The growth of the fish and its scales are proportional in the early years of life, until the fish reaches a certain size, which, for the Icelandic haddock, is 39—44 cms. After this the scales grow proportionally faster than the fish does. 3) Finally the selection of scales is of great importance, as the scales grow with different rapidity according to the part of the body they cover. Every scale grows proportionally with the fish, but the actual growth rate of the scale depends upon its position on the body.

Dr. Thompson has succeeded in identifying the regions in which the various year classes from recent broods are distributed, by calculating, for example, the growth rate of the haddock in different parts of the Icelandic waters by means of scale examinations. Thus valuable conclusions could be drawn as to the biology of the fish, especially in regard to its migrations. It is a well known fact that the haddock spawns on the south and west coasts, the spawning culminating in April. The I-group is found chiefly on the south and west coasts, more rarely on the north coast and only exceptionally on the east.

The haddock stock of the south and west coasts varies with season. Mature fish gather in abundance on the spawning grounds here, but young fish may also be found in their immediate neighbourhood. East Icelandic waters do not possess any distinct stock: a few old mature recovering spents are found here, and in exceptional years the I-group can be taken in great quantities. This group sometimes appears on the north coast and remains there until maturity is reached, in company with fish which have migrated hither from the south and west coasts in the first three years of life. Although the brood comes to the east coast in exceptional years, it only remains there for a short while, and in the second year it leaves the east coast for the north, where it grows up. On the south coast growth takes place practically the whole year round, but on the north and east coasts it occurs chiefly in the late summer months. This is perhaps connected with the food supply, as the sand eel generally seems especially to favour growth. Secondly growth is both directly and indirectly dependent on temperature. Lee's suggestion that the central body of the scale is compressed when new sclerites are added cannot be maintained. The morphology of the scale prevents such compression.

When 5—6 years old the haddock gather on the spawning grounds in

order to spawn, and the spawning shoals are then of mixed growth types, of course.

When dealing with haddock more than six years of age, scale examinations are required in order to find out where the specimen in question spent its immature years. The Icelandic haddock material now available is too scanty to allow conclusions to be drawn in regard to the actual extent of the annual recruitment, but it can yield comparative information on this point. The years 1899?, 1904, 1922 can be indicated as very good brood years, 1901, 1902, 1908 and 1909 as poor. The results of trawling for a standard time (10 hours) with a sixty foot otter trawl can be used as a measure of the relative abundance of a brood. When two thousand specimens of a particular brood are taken in the I- to III-group stages by trawling for the standard time on the south or west coast, the brood is denominated as normal. If, on the other hand, the catch is much less or greater than this, the brood is considered as abnormal. This is also the case if the I- to III-groups are distributed mainly on the north and east coasts.

The Icelandic haddock stock is independent of that of other countries but does not represent any distinct race. The growth rate of the Icelandic haddock and the morphology of its scales differ very much from those of North Sea haddock, but are more closely connected with those of the Faroe haddock.

It is to be hoped that the methods employed by Dr. Thompson in this paper will be more widely applied to the biology of other Icelandic food fishes, e. g., the cod. Undoubtedly it would then be possible to answer many biological questions which still remain to be settled. It is of great importance to be able to establish the hydrographical conditions responsible for the transport of a brood to a certain part of the coast and the circumstances which give rise to a specially favourable distribution. The locality in which the fish spends the first years of its life has a great influence upon its size and weight, which have an interest from a commercial point of view. On the other hand, as the author shows, the growth rate and the locality in which adolescence is spent influences the time of reaching maturity. Consequently the longer it takes the fish to grow up, the less is the productivity.

When these problems are elucidated, and a method is found for enumerating the stock of haddock or of any other fish, it will be possible to predict the fishery for the coming years, which is one of the aims of the investigations. A good beginning is made with Dr. Thompson's valuable work.

A. F.

Harold Thompson. Haddock Biology (North Sea). A brief Survey of recent Data, Methods and Results. Cons. Perm. Int. pour l'Explor. de la Mer. Rapports et Procês-Verbaux, Vol. LIV, pp. 135—163. Copenhague, 1929.

Diese Arbeit ist ein kurzer Auszug einer ausführlicheren Darstellung die dem Nordsee-Ausschusse der Internationalen Meeresforschung während ihrer Sitzung in Kopenhagen in 1928 vorgelegt wurde; sie enthält

eine kurze Übersicht über das reiche Material zur Biologie des Schellfisches, das in den Nachkriegsjahren seitens der schottischen Fischereiuntersuchungen mit preiswerter Regelmässigkeit gesammelt wurde. Es wird auch eine Einführung in die Bearbeitungsmethoden gegeben sowie eine Übersicht der Hauptresultate.

Es ist sehr zu begrüssen, dass eine so gedrängte Darstellung eines grossen Materials und einer weitläufigen Bearbeitung gegeben wird. Dadurch werden die gewonnenen Gesichtspunkte erst weiteren Kreisen zugänglich gemacht, die wohl an den Hauptzügen, zum Vergleich mit verwandten Problemen, interessiert sind, nicht aber die nötige Zeit oder Spezialkentnisse zum Verwerten der grossen Menge von Einzelkeiten aufzubringen vermögen.

Das Material besteht aus Messungen, Wägungen und Altersbestimmungen (nach den Schuppen) von den durch viele Hunderte von Schleppnetzzügen des schottischen Untersuchungsdampfer »Explorer« erbeuteten Schellfischen aller Grössen von etwa 14 cm aufwärts. Die geographische Klassifikation erfolgte unter Benutzung von sehr zweckmässig gewählten Einheitsrechtecken von je 1 Längengrad und $^1/_2$ Breitengrad.

An der Hand eines Beispieles von 10 am selben Ort in einer Woche gemachten Zügen wird zuerst diskutiert, inwieweit der einzelne Zug in Bezug auf den dem Rechtecke und dem Zeitpunkt entsprechenden Schellfischbestand repräsentativ ist. Es wird zugegeben, dass die Ergebnisse zwar sehr schwankend sind, jedoch vollkommen charakteristisch, wenn man sie mit solchen aus anderen Jahreszeiten, anderen Gebieten oder anderen Jahren vergleicht.

Es wird gezeigt, dass man bei der Altersanalyse bei weitem nicht alle Individuen einer Probe zu bestimmen braucht, da bei den jüngeren Jahresklassen (und es handelt sich hier doch wesentlich um die 4 oder 5 ersten) das Alter aus der Grösse allein unter Berücksichtigung des speziellen Fanggebietes hervorgeht. Man kann sich zuweilen mit nur 30 % Schuppenablesungen begnügen.

An der Hand vom berechneten Erstjahrswuchs wird gezeigt, dass die Wachstumsbedingungen in der südlichen Nordsee am besten sind, im Norden, östlich von Shetland, dagegen am schlechtesten. Trotz der Wanderungen kann dieser Unterschied auch bei den späteren Jahresklassen verfolgt werden.

Es wird gezeigt, dass die Fischerei jetzt fast völlig auf die ersten vier Jahresklassen angewiesen ist und dass man bei der intensiven Befischung nicht mehr erwarten kann, dass wesentliche Mengen von grossen Schellfischen, so wie es in den Anfangsjahren der Schleppnetzfischerei oder gerade bei Kriegsende der Fall war, jemals mehr in der Nordsee zu erbeuten sein werden. Auf der anderen Seite hat es sich auch erwiesen, dass selbst in einem Jahr mit scheinbar äusserst geschwächtem Bestand ein überaus reicher Jahrgang entstehen kann, wie z. B. derjenige von 1923.

Unter Heranziehen von älterem Material wird in einer Figur, die in ihrer Einfachheit sozusagen die Quintessenz der Untersuchung darstellt, gezeigt, dass es in den 25 Jahren von 1902 bis 1927 fünf sehr gute, neun mässige und 10 arme Jahrgänge gegeben hat. Von den Jahrgängen 1914 und 1915 ist zu wenig bekannt, um sie in diesem Zusammenhang mitnehmen zu können.

Eine sehr grosse und nützliche Arbeit ist in die kartographischen Darstellungen gelegt. Vielleich hätten die Karten etwas an Klarheit gewonnen, wenn für Bestandsdichten nur zunehmende Schwärzung und keine Zahlen oder Mengensymbole verwendet worden wären. Die Tabellen A, B, C und E verdienten, in graphischer Form gegeben zu werden. O. S.

H. M. Kyle. Die Statistik der Seefischerei Nordeuropas; from Lübbert and Ehrenbaum's Handbuch der Seefischerei Nordeuropas. Bd. X, Hft. 4. Stuttgart, 1928.

In the writing of comprehensive "handbooks" the Germans have, on the whole, the advantage of us. We have produced an Encyclopedia Britannica, an Oxford Dictionary, an Index Kewensis; but we left it to them to produce a Thesaurus of the Latin language, and a "Tierreich", or fauna of the world. We have not even achieved, nor attempted, a fauna of our own country or our own seas. Abderhalden's biological and physical "Arbeitsmethoden", and several other great compilations besides, come into one's mind as examples of the industry of German scientific men and the enterprise of their publishers; and now we have, for our own subject, the Handbuch der Seefischerei Nordeuropas, edited by two well-known and most competent authorities, and containing in ten stately volumes a complete account, biological, technical and commercial, of the fish and fisheries of the northern countries.

Dr. H. M. Kyle seems to be the only Englishman who has taken a share in this great enterprise; but his share is a large one, and his industry is equal to that of his German colleagues. We have had from him in recent years his "Biology of Fishes", his work on the Pleuronectidae, his chapters in the Fauna der Nordsee; and now he has written a large and handsome volume for the present Handbook, dealing with the whole subject of the British Sea-fisheries, their history, legislation, harbours, boats, gear, fishing-grounds and all the rest of the complicated story. For the moment we are not concerned with this large work, but only with a chapter, contributed to another volume, in which Dr. Kyle epitomises the statistics of the north-european fisheries.

This is a matter which the International Council has always had at heart, and which is dealt with on an international scale in an annual Statistical Bulletin. Of this Bulletin, originally planned by Dr. P. P. C. Hoek, Dr. Kyle was editor for several years. After his resignation, and just before the war, a Committee, greatly strengthened by the presence of Sir Henry Rew as advisory expert, revised the plan of the Bulletin and improved it greatly, as many of us thought; but it is hardly to be wondered at, perhaps, that Dr. Kyle likes it better as it was in his time and in his own hands. He is troubled because the Bulletin gives less help than was at first hoped and planned for in regard to what we may call biological rather than merely commercial details; but it is open to us to hold, on the other hand, that questions of local distribution and fluctuations of local abundance could never be dealt with in this brief Bulletin of ours. They have their proper place for statement and discussion in special reports, whether of the Fishery Departments or of the International Coun-

cil. Such as the Statistical Bulletin is, for better or for worse, Dr. KYLE makes abundant use of its contents; and, save for one or two small additions, he draws from it practically all the statistical material of his book. He makes an extremely good job of it; in less than thirty pages he gives just such a clear and comprehensive abstract of the international statistics as we should expect or look for in a Handbook or Encyclopedia of the kind.

As an appendix to this statistical chapter, Dr. KYLE gives us a short essay on the "question of overfishing". Remembering, as no-one is better able to do, how sweeping and how confident were the statements made on this matter thirty years ago, Dr. KYLE begins by explaining how much more difficult the question appears to us than it was then supposed to be, and how manifold are the component parts of the entire problem. He then gives a table of the North Sea catch of the principal fishes during two periods of five years each, pre-war and post-war, and proceeds to draw a comparison between them. He finds that the average total catch of fish by all countries in the North Sea (Norway and Sweden excepted) was less in the period 1921—1925 than in 1909—1913 by 225,000,000 kgs. per annum. This means (by the way) a diminution of about 21 per cent.

But immediately afterwards the remarkable fact appears that the said diminution was precisely equivalent to, or was in short wholly accounted for, by a diminution in the herring catch alone; and that several fishes, for instance haddock (but not cod), saithe, skate, sole, halibut and brill, all showed an increase instead of a decrease, on the average of the five post-war, as compared with the five pre-war years.

Dr. KYLE then discusses the plaice-question in the Cattegat, Baltic and North Sea, chiefly on the basis of Dr. C. G. JOH. PETERSEN's work in the one region, and that of Dr. HEINCKE and his friends at Heligoland in the other. Some of the results arrived at are truly astonishing; and with all regard for the abilities, experience and perfect sincerity of the authors concerned, one cannot help wondering whether all of these statements will be fully substantiated, and stand the test of time. We are assured, for example, that at Heligoland in 1905 the average size of five-year old plaice (males) was 30 cm., but was only 22 cm., at the same age, in 1925; that similarly, the six-year old plaice in the former period were 38.5 cm. long, but in 1925 were only 25.8 cm. — just two-thirds of the former magnitude. We are assured again (and the authority is high, however astonishing the statement may seem to be) that in 1921 the three-year old plaice were 35 cm. long in the Kattegat, 18 cm. at Nissum, and only 17 cm. in the North Sea — less than half their size in the Cattegat. The immediate inference is drawn that the Cattegat had greatly benefited by the severe and intensive fishing to which it had been subjected; while the North Sea was none the better, but much the worse, for the protection which its fisheries had received during the war. A dwarfed or starveling race of plaice had grown up there, instead of well-fed and prosperous broods.

Among other interesting conclusions to which Dr. KYLE is led, he gives a calculation to shew that in 1925 there were, at a minimum, more than ten times as many female plaice in the North Sea as were

required for breeding purposes. He looks to the Danish seine, and its increasing and extended use, for the steady improvement of the plaice-fishery. In the next few years, he tells us, the plaice-population of the North Sea will be brought more and more, by help of this engine, into a state like that already established in the Cattegat; in other words, the rate of growth will be immensely accelerated as the stock is thinned out more and more, and the proportion of "small fish" in the catch will be proportionately diminished. On the other hand, any attempt to protect the small fish will, he thinks, be unfortunate and mischievous; it will only lead to the production, once again, of a race of dwarfs, — of lean and hungry fish, which need five to seven years, instead of two, to make them fit for market.

These views are revolutionary indeed, compared to some which we were brought up to believe; but Dr. KYLE is by no means alone in holding them. We know how Professor GARSTANG said much the same thing many years ago, and has been saying it of late again. Right or wrong, it is a view which deserves, and is receiving, the careful consideration of us all.

D'ARCY WENTWORTH THOMPSON.

A. LUMLEY, J. J. PIQUÉ, and G. A. REAY. The Handling and Stowage of White Fish at Sea. Dept. of Sci. and Ind. Research. Food Invest. Special Rept, no. 37. London, 1929.

This report is a proof of the sincere desire on the part of the Department of Scientific and Industrial Research to help the Fishing Industry.

The investigation has been extremely thorough and minute attention has been given to all practical details, but despite all this neither at Aberdeen or Milford Haven, where the actual experiments were made, have any of the methods outlined in the report been adopted by any of the Trawler Owners.

Although the Steam Trawling Industry is a highly technical one, apart from an increase in size and improvement in the general design of the hull and engines on the part of the Builders the handling and stowage of fish at sea has certainly in the United Kingdom not received the attention it has merited.

The Industry itself does not attract, nor have even the largest Owners offered sufficient inducement to, educated trained technical men to enter it: thus it has been somewhat slow in emerging from its older self; inter-jealousy between the Ports in the past has prevented healthy co-operation and the pooling of ideas, which would have been helpful to the Industry as a whole.

I have never agreed that the responsibility of landing fish in the freshest possible condition should rest solely on the Mate; the Skipper should be mainly responsible, and, if the Mate does not carry out certain well defined rules to ensure efficient stowage and landing the fish as fresh as possible under the prevailing conditions, change him. However, the Mate has often been unjustly blamed for the bad condition of the fish landed, when the fault lay mainly with the Owners who were penny wise and pound foolish and did not supply sufficient ice.

In 1904, when the writer took over control of the Castle Co. at Milford Haven, 8 tons of ice was considered ample for a 10 to 12 day trip; at that time large individual catches were frequent and at least 12 to 18 tons of ice should have been the minimum.

The report has made abundantly clear the great economy resulting from the use of ample ice. I do not agree, however, that the ice should be in contact with the fish; careful and prolonged experiments in France have proved that with ice as a cooling medium two things are essential to keep fish fresh and ensure the best results:—

1. Exclusion of air as far as possible.
2. Harmful effect of melted ice in direct contact with the fish.

With regard to the difficulty of persuading the Industry to adapt themselves to novelty, while innovations may be difficult to introduce to many shore Industries, conditions at sea, lack of space etc. render them much more difficult on a trawler.

The cost of the scheme need not be necessarily very low; the extra demand created by really fresh fish would repay the Owner. Much more serious is the cost of maintenance and working; if two extra hands are employed, labour alone would account for £ 400 per annum, and as this is more than the Industry can bear at the present time, I agree entirely with the Report's recommendation that simplicity in operation is essential.

Washing of individual fish is out of the question with large catches of medium and small fish, and already fish suffer from too much handling.

The boxing of fish would undoubtedly land fish in better condition and reduce handling, but with the small crews carried on British trawlers, outside of the fleeters, this method is not at present practicable with ordinary mixed catches; although the French have for several years with their large crews boxed successfully trawled herrings, they do not apply boxing to the mixed varieties of white fish.

The Report confirms the view that refrigeration is not necessary on trawlers that make trips not exceeding 14 days.

Inland merchants are unanimous regarding the inferiority of refrigerated fish; even that treated by the very latest known methods has proved inferior and less marketable than fish kept with ice only as the cooling medium.

Insulation is a necessity, and all trawlers should have efficient insulation; much of it to-day is *very inefficient* and the majority of the older vessels are not insulated. From a hygienic point of view galvanized iron shelves are excellent. Most of the fish holds, after the enamel paint has worn off, are not ideal for keeping fish; the sodden pound boards are usually scrubbed in a dirty tub of very foul water; the majority of Owners do not thoroughly dry and re-enamel the fish room and pound boards except at rare intervals.

I regret that space has not permitted me to deal more in detail with this excellent Report; the biological and physical observations are illuminating and instructive and of great value to the Industry, and although at present the Trawling Industry has not adopted the special gutting troughs, sterilizing plant etc., the Report will have rendered excellent service if it brings home to Owners, Skippers, and Crews the benefits which will result from greater care in handling and stowage of white fish at sea.

CRAWFORD HERON.

E. Ehrenbaum. Der Flussaal, *Anguilla vulgaris* Turt. Handbuch der Binnenfischerei Mitteleuropas. III. E. Schweizerbart'sche Verlagsbuchhandlung (Erwin Nägele). Stuttgart 1930.

The present paper, which has appeared as a reprint from the large work "Handbuch der Binnenfischerei Mitteleuropas", is dedicated to the Danish biologist, Professor Johs. Schmidt, "the keenwitted and successful investigator of the life-history of the eel".

It may be said at once that this paper is clear, compact and up-to-date and gives, so far as is possible in the limited space, a comprehensive account of the biology, the economic value and the practical fishery of the european eel. As the whole paper covers only about 60 pages with numerous illustrations, it has naturally been impossible to give a more detailed view of all the different questions in connection with the life-history and the economic importance of this fish, but looking through the paper, the reader will be surprised at the number of details to be met with.

One of the most interesting sections of the paper is that which deals with the propagation and the young stages of the eel, and here we find a short review of all the important investigations of Professor Schmidt. In the most clear and attractive manner a description is given of the different expeditions with a short statement of the results which were obtained on the various cruises in the Atlantic. Furthermore, the author mentions the few points regarding the breeding of the eel which are still open to question. In the other sections relating to biology, we find a discussion of all the most important points of interest, as migration, food, growth, enemies and diseases of this fish, together with a description of the differences in the appearance and development of the sexual organs.

The paper is concluded with chapters on the economic value of the eel fishery, and on the fishing gear and methods of fishing. Here the author gives a particularly interesting account of the importance of and the practical details relating to the transplantation of elvers from Atlantic coastal waters to the continental countries of Europe.

Naturally the present paper essentially comprises a summary of previously published observations, but it gives in the most excellent manner a survey of our knowledge of the eel. The style is simple and agreeable, so that not only scientists but also readers who may have only the slightest interest in biology will be able to read it with advantage. P. Jespersen.

C. F. Hickling. A contribution towards the life-history of the Spur-dog. Journal of the Marine Biol. Association. N. S., Vol. XVI, No. 2. Plymouth 1930.

Die zahlreichen Untersuchungsfahrten, welche der Verfasser im Auftrage der englischen Fischereibehörde in den letzten Jahren zum Studium des Seehechts (*Merluccius*) unternommen hat, gaben ihm Gelegenheit, auch andere Fangobjekte in den Kreis seiner Forschungen zu ziehen, und die oben genannte Veröffentlichung gibt davon bezüglich des Dornhais (*Acanthias vulgaris* Risso) interessante Kunde, die die früher in der gleichen Zeitschrift (Vol. XII, p. 468) veröffentlichten aufschlussreichen Mittei-

lungen von E. Ford vorteilhaft ergänzt. (Dr. J. R. Norman macht darauf aufmerksam, dass die richtige Benennung dieses Fisches ist *Squalus acanthias* L. Journal du Conseil 1930, p. 261).

Die ungewöhnlich grossen Tiefen, in denen die Untersuchungen über den Seehecht zum Teil vorgenommen wurden, gaben Gelegenheit, das Verhalten des Dornhais in diesen Regionen kennen zu lernen, wo er bisweilen (z. B. im Gebiet der Faeroe-Shetland-Rinne) neben dem Kohlfisch als einziger Nutzfisch angetroffen wurde. Die in der Tiefe gefangenen Dornhaie waren durchweg grösser als in den flacheren Gebieten, und zwar wurden die männlichen Fische in flacherem Wasser angetroffen als die Weibchen gleicher Grösse. Aber die grossen trächtigen Weibchen machten insofern eine Ausnahme, als sie meist auf der Wanderung in flacheres Wasser beobachtet wurden.

Nach Ausweis des Leber- und Fleisch-Gewichtes waren die Dornhaie des tieferen Wassers meist in besserem Ernährungszustand, doch ist das wohl nicht als feste Regel anzusehen.

Das Lebergewicht nimmt in beiden Geschlechtern mit der Länge zu, ist aber beim Weibchen gewöhnlich höher. Trächtige Weibchen büssen ihren Ernährungszustand ein bei der Wanderung auf flacheres Wasser.

Verfasser vertritt die Ansicht, dass der bessere Ernährungszustand in tieferem Wasser der günstigen Einwirkung des höheren Druckes auf den Stoffwechsel zuzuschreiben ist, da derselbe dem Aufbau von Reservestoffen günstiger sei als dem Abbau. Der erhöhte Stoffwechsel in der Zeit der Geschlechtsreife veranlasse daher die grösseren Fische tieferes Wasser aufzusuchen, und zwar die aufbauenden Weibchen in stärkerem Masse als die Männchen. Eh.

H. S. Davis. Care and Diseases of Trout. U. S. Department of Commerce, Bureau of Fisheries, Document No. 1061. Washington, 1929.

This report has as its subject trout breeding in the United States of America, where trout farms are conducted by the government as well as by private persons.

The increasing demand for large trout for stocking purposes has added to the problems of the breeder, who has now to keep fish growing and in health until they are large enough to satisfy the demands of the customer. Mr. Davis deals with the methods by which this can be successfully done. *Salvelinus fontinalis* is the trout to which reference is chiefly made.

The first section of the paper is on the care of fingerling trout. It is the aim of the breeder to reproduce natural conditions as far as possible, and the methods of doing so are discussed in detail. Out-of-door raceways are recommended as the best means of holding fry as soon as they begin to feed. The next section deals with the care of raceways and ponds.

As regards the food best suited to the requirements of trout, a mixture of beef heart and liver is recommended as the best diet for young fish, while older fish thrive well on fresh meat combined with dried animal products (fish meal etc.). Dried vegetable products (cereals and beans), when well cooked, may be used. A certain proportion of fresh meat is essential for health. These observations are founded on the results of feeding ex-

periments conducted in state hatcheries, and reference is made to experiments which are being carried out on the value of addition to the food of cod liver oil and dried yeast.

The improvement of stock by selective breeding is referred to, and mention is made of the observation that better results are obtained in a hatchery with ova from "home bred" stock, than with any other ova.

The rest of the paper deals with parasites and diseases of trout. The various diseased conditions prevalent in the United States of America are recorded, and lucid descriptions of the causative organisms, appearances of diseased fish, and methods of control and prevention, are given. Disease in trout may be due to bacteria, protozoa, parasitic worms and crustacea, while fungi of the genus *Saprolegnia* may also infect fish, although such infection is usually secondary to another condition. Bacteria and protozoa are the chief causes of serious infectious disease in trout. External parasites, — certain worms, crustacea, and protozoa, — may be controlled by immersion in salt baths, or in baths of copper sulphate or potassium permanganate solutions. Internal parasites are difficult to deal with, and in their case, "prevention is better than cure".

The following parasites and the conditions they produce are described:—

external animal parasites; *Gyrodactylus* (common in hatcheries), *Discocotyle salmonis*, both Trematode worms; *Salmincola edwardsii*, a copepod parasitic on *S. fontinalis*; and *Ichthyophthirius*, *Cyclochaeta*, *Chilodon*, and *Costia*, all protozoa which sometimes affect trout:

internal animal parasites; parasitic worms, which do little serious harm; *Octomitus salmonis*, a protozoan parasite which may cause serious mortality among young trout; and two other protozoa, *Schizamoeba salmonis* and *Chloromyxum truttae*, which are comparitively uninjurious.

Bacterial diseases. Furunculosis is the chief of these, and Mr. Davis gives an account of the various symptoms, which are already only too well known in this country. He states that this disease may occur in a large number of fresh-water and marine fishes. It would have been interesting if the authority for occurrence in marine fishes had been stated, as investigators in Britain at least have not yet encountered an authentic case of furunculosis in sea fish in natural conditions. The difficulty of treatment of this disease is recognised, and destruction of diseased fish, which should be burnt or buried in lime, together with disinfection of ponds is advocated. The danger of spread of the disease by transportation of fish and other material is also emphasized.

Gill disease and fin rot are also described, but the specificity of the supposed causative organisms does not appear to have been established by experimental methods.

Thyroid abnormality, due to insufficiency of iodine and possibly also to general bad conditions, is mentioned, and several diseased conditions, — "popeye", "white spot" disease in ova and fry, "blue spot disease" in fry, and soft eggs, — are stated to be due to a variety of non-specific causes.

This paper will be of special interest to fish culturalists in Britain, where the results obtained in trout breeding are not published; and the descriptions of parasites and diseases will be helpful, for although *S. fontinalis* is not commonly reared outside of the United States, in many cases

the same parasites or others closely related affect different species of the Salmonidae. Isobel Blake (I. J. F. Williamson).

H. Henking. Untersuchungen an Salmoniden mit besonderer Berücksichtigung der Art- und Rassenfragen. Teil I. Cons. Perm. Intern. pour l'Explor. de la Mer. Rapp. et Proc.-Verb. Vol. LXI. Copenhague, 1929.

Investigations on the Salmonidae have usually been made in the interests of people concerned with the regulation and improvement of the commercial fisheries or by anglers interested in the life-history of their prey. They have dealt with the Salmonidae of a particular river and they have endeavoured to explain fluctuations in abundance by changes in the conditions of existence within the river they are immediately concerned with. The wide range of variability and close adaptation to environmental conditions to be observed in salmon and trout, together with the urgent necessity for knowledge which will provide for the solution of administrative problems have led to the restriction of our knowledge of these fish within a series of compartments, as though the salmon and trout of each river constituted distinct species to be investigated separately. The results so far obtained have failed to provide a method of foretelling or accounting for the dimensions of the annual run of salmon, and it is now apparent that the solution of the problem depends, to a large extent, on acquiring some knowledge of what happens to the salmon in that period of its life after it disappears into the sea as a smolt and before it approaches the coast and returns to the river for the purpose of spawning. Unfortunately, so far as the salmon in the Atlantic is concerned, little or nothing is known of the extent of its migrations or of its food or habits in the sea. Very few salmon have ever been caught in the open sea. Either they resort to some part of the Atlantic not frequented by fishermen or they are able in some way to avoid the nets. The endeavours now being made to relate the dimensions of the salmon runs with hydrographic conditions in the Atlantic or with the movements and numbers of the herring are praiseworthy but not promising.

In these circumstances we may hopefully anticipate that a great deal of information likely to assist in filling the blank in our knowledge of the Atlantic salmon may result from the investigations now being carried out in the Baltic area. There is no evidence that there is any mingling of the stocks of Atlantic and Baltic salmon, and no salmon marked in the Baltic or any rivers flowing into it have ever been caught outside it. Within the Baltic area the salmon, after their descent from the rivers as smolts, undertake very extensive migrations. They frequent the shallower banks, especially in the southern part of the Baltic, where they appear to feed mainly on sand eels (Ammodytes). There is an intensive fishery for salmon in the Baltic, largely in international waters. Salmon smaller than 40 cms. which have spent nearly one year in the sea are seldom caught, probably because, as Dahl suggests, they lead a pelagic life, but fish from 40 cms. upwards may be caught in some part of the Baltic throughout the year. There has been in recent years a marked reduction in the catch of salmon both in the Baltic and in the rivers flowing into it, a reduction which has

excited some apprehension, and investigations on salmon and sea trout are being carried out by all the countries bordering the Baltic.

The sea trout which frequent some of the rivers flowing into the Baltic attain a large size, comparable to that of the salmon. There appears to have been, in the past, some confusion as to the specific characters distinguishing salmon from sea trout, and fears have been expressed that crossing between the two species occurs frequently. It has apparently been the practice in some hatcheries to use salmon, sea trout and even brown trout indiscriminately for purposes of artificial propagation.

Accordingly, after some discussion in the Limnological Committee of the International Council, Professor HENKING agreed to prepare a Report on the Salmonidae, dealing with these matters amongst others, and at the meeting of the Council in June, 1928, at Copenhagen, the Committee recommended that Professor HENKING be asked to prepare the first part of his Report dealing with racial studies of salmon and trout. This Report has now been published by the Council.

The report begins with a discussion of the migrations between fresh and salt water of the Salmonids found in the Pomeranian river Persante. They consisted mainly of sea trout, salmon being relatively scarce. Details are given of the length, weight, colour of the adipose fin, size and condition of the ovaries, stomach contents, number of gill-rakers, co-efficient of condition, and the number of rays in the various fins.

The structure of the vomer, the os linguae and the gill-rakers is then investigated for the purpose of finding characters by which salmon could be distinguished from sea trout. The observed distinctions are fully explained, with the aid of numerous figures. In this connection it may be remembered that a proposal is under consideration to fix an international minimum size limit of 35 cms. for salmon and sea trout in the Baltic, for the purpose of protecting the salmon. This size limit is too low to afford any practical protection to the salmon and was chosen because of the difficulty experienced by fishermen in distinguishing between salmon and sea trout. If some ready method of differentiating the two species on external characters could be developed, it would permit a higher size limit to be fixed for salmon. Unfortunately the characters investigated by Professor HENKING do not assist to this end.

On the question of hybridisation between salmon and trout under natural conditions, Professor HENKING still retains an open mind. The two species have been frequently crossed in hatcheries and the alevins appear to hatch out in a normal manner, but the subsequent fate of the hybrids has not been traced. Professor HENKING describes a marked and recaptured fish of 42.4 cms. which he regards as probably a hybrid and which was the result of artificial fertilisation in a hatchery. There is no reliable evidence that hybridisation occurs to any extent under natural conditions, otherwise our rivers would be full of hybrids. The time and place of spawning differ usually in salmon and trout; the sperm of trout and probably those of salmon remain active for only about two minutes. Unless the ova are promptly fertilised by the sperm of the attendant male, they are buried in the gravel of the redd where their chance of being fertilised is greatly reduced.

Of particular interest is Professor HENKING's study of the scales of 15 Salmonids, mostly sea trout, of precisely known age, ranging from six months to seven years. The fish resulted from ova artificially fertilised in a hatchery, marked in the following October, liberated in the Persante and subsequently recaptured. Excellent illustrations are given of scales from each fish.

A brief account is given of the results obtained by transplanting young brown trout reared in ponds to the slightly saline water of the Baltic, and of the subsequent rapid increase in size.

Professor HENKING is to be congratulated on the completion of the first part of his task. R. SOUTHERN.

W. C. HERRINGTON. The Pismo Clam. Further Studies of its Life History and Depletion. Fish Bulletin No. 18, Division of Fish and Game of California. Sacramento. 1930.

This paper deals with investigations into the life-history, rate of growth, fluctuations in abundance, and other problems relating to the Pismo Clam, *Tivela stultorum* (Mawe), and its fishery. This lamellibranch occurs on many of the exposed beaches of California, where it is greatly esteemed for the table. It inhabits the inter-tidal zone of sandy beaches down to extreme low water mark, and extends to the surf beaten sand bars beyond, but is probably not found outside them. The densest population is found in the inter-tidal zone, but the largest examples occur mainly in the surf line beyond. The clams are dug out by means of rakes and forks, the latter being usually employed where the sand is fine and hard packed. In an average of the shellfish marketed in California during the years 1917—1926, the Pismo clams occupied third place in importance as regards weight. The investigation was undertaken mainly to discover the causes of fluctuations in the fishery and to devise corrective measures.

Measures for the safeguarding of the fishery have been in force since 1911. At present the legal size stands at five inches diameter, the catch being limited to fifteen clams per person per day. An annual census of the clams inhabiting a strip of the intertidal zone on various beaches has been taken since 1922, while, at the same time, samples of the commercial catch have also been examined. It was found that the number of growth or annual rings formed in most cases a fairly reliable index to the age of the animals. Growth differs somewhat according to locality, and is not noticeably affected by the crowding of the habitat by dominant year classes. Spawning begins in the third or fourth summer, the number of eggs being closely related with the weight of the clams. The number of eggs produced is enormous, a fact which indicates that the mortality during the larval stages is very high, as the adult clams do not appear to suffer unduly from the attacks of pests or natural destructive agencies. The appearance of dominant year-classes at intervals of from five to seven years was indicated from a study of the evidence gained from various sources, such succesful year classes affecting the catch during subsequent seasons. The investigation showed that in four to seven years following the appearance of a dominant year group the clams reach legal size, and in one to

three years more they disappear from the areas of greatest abundance owing to the effects of fishing. The amateur diggers are believed to be responsible for the greater share in the depletion of the inter-tidal zone of the Pismo-Oceano Beach, while at Morro the most important factor is probably the commercial catch. The problem of safeguarding the fishery resolves itself into one of making the produce of a dominant year-group bridge the period between it and the next one. The strict enforcement of the present legal size is advocated, so as to allow the clams to reach such a size that they may spawn once or twice before being caught for the market. It is also suggested that a certain degree of improvement might follow on the limitation of the number of diggers, or in the number of clams permitted to be taken. It is admitted that the prospects of the fishery are not very bright as regards the future.

This excellent paper is well produced, and is illustrated by a number of diagrams and photographs, and the investigation may well serve as a model to those who have to undertake similar researches. F. S. W.

G. C. Robson. On the Dispersal of the American Slipper Limpet in English Waters (1915—29). Proc. of the Malacological Society, Vol. XVIII, Pt. VI, pp. 272—5, November 1929.

This short paper deals with the spread (in British waters) of the Slipper Limpet (*Crepidula fornicata*, Lamarck), a mollusc from the U. S. A. which has become a pest on British oyster beds. The period covered by the records is that between 1915 and 1929. In a former paper by the same author, published in 1915, and quoted herein, it was stated that this species occurred at various places between the Isle of Wight and Woodbridge (Suffolk), and that there was a secondary area of dispersal on the Lincolnshire coast and at Cleethorpes on the Humber. It was not known whether these two areas were continuous, or whether they represented two points from which *Crepidula* had spread from separate introductions from American stock. The author discusses the question as to whether *Crepidula* has spread to various places during the larval stage, or whether the adults were transported by various agencies, such as the bottoms of ships. In a useful table recording the occurrence of *Crepidula* at various places between the Lincolnshire coast and Studland, Dorset, between 1887 and 1929, reference is made to a Dutch record by Tesch of *Crepidula* being found at Great Yarmouth in 1923. This record, in the author's opinion, seems to place some difficulties in the way of Orton's theory of larval distribution, if it be assumed that it had spread northwards from Essex waters, where it seems to have appeared about 1890, and he believes that it may possibly have been introduced from the Lincolnshire coast. The need for basing records on sufficient evidence is emphasised by Robson, and the necessity for it seems to be borne out by the case of the Great Yarmouth record. Enquiries instituted here recently would seem to render its authenticity somewhat questionable. Subsequent to the publication of Robson's valuable notes, information has been received of further occurrences of *Crepidula* on the Dutch oyster grounds, and the problem is receiving close attention. It may also be mentioned that this mollusc appears to attain

a much larger size in European waters than in its original habitat, where, moreover, on the authority of American biologists, it is not regarded as a pest on oyster beds. F. S. W.

W. Nienburg. Die festsitzenden Pflanzen der nordeuropäischen Meere. Handbuch der Seefischerei Nordeuropas Bd. 1, H. 4, Pp. 1—54 with 20 Figs. Stuttgart 1930.

This account of the attached vegetation of the North European seas begins with a short consideration of the environmental factors which might with advantage have been very much more detailed. The importance of the amount of light reflected from the surface of the water, of the amount of light absorbed and the respective influences of the direction of the sun's rays and the transparency of the sea water upon the depth and zonation of vegetation would have been better apprehended if concrete data had been quoted. The treatment of these factors which occupies about two pages is followed by a general systematic account of the attached vegetation in which special features of the various algal groups are considered. A short section on the higher plants deals only with *Zostera* and *Salicornia*. As the latter is included it is difficult to understand why other intertidal genera are omitted. The rôle of the genus *Salicornia* in tidal areas is an important one but can only be appreciated if the segregates of *Salicornia herbacea* are distinguished.

The most useful part of the work, because so rarely dealt with, is the section concerning the geographical distribution. The following geographical elements are recognised:— Cosmopolitan, e. g. *Ulva lactuca*, *Ceramium rubrum*; North European, e. g. *Enteromorpha intestinalis*, *Fucus vesiculosus*, *F. serratus*, *Cladophora rupestris*; Arctic, e. g. *Laminaria solidungula*, *Lithothamnion foecundum*; Arctic-French, e. g. *Chaetomorpha melagonium*, *Elachista fucicola*; Southern, e. g. *Chaetomorpha crassa*, *Bostrychia scorpioides*; Norwegian-Southern, e. g. *Bryopsis plumosa*, *Dictyota dichotoma*, *Chrondrus crispus* and the West European-Baltic, e. g. *Pelvetia canaliculata*, *Polysiphonia violacea*. These geographic groups are illustrated by maps shewing the distribution of typical members.

There follows a consideration of the plant communities as recognised by Boergesen, their zonation and the relation between the vegetation and Fauna. The whole forms a useful summary, though a fuller treatment of the factors involved would have added materially to its utility. E. J. S.

H. Blegvad. Mortality among animals of the Littoral Region in Ice-Winters. Rep. Dan. Biol. Station no. XXXV, Copenhagen 1929.

In the Danish waters the very cold winters regularly give rise to large quantities of ice, and, in the fjords, the ice which often reaches half a metre in thickness covers the water for several months. As the water-level varies the ice breaks up against the beaches and may later on freeze together again. In the open waters, however, the ice is normally formed as small disks which may later freeze together into a solid mass, to be broken up again by the waves and currents.

From olden times it has been known that in very severe winters fish and other animals are to be found dead along the beaches, but nothing, or very little, has been done to collect the evidence and report upon the matter.

It is to the credit of H. Blegvad to have taken up for examination the very important problem of the mortality among the animals of the littoral region.

The winter 1928 1929 was the coldest for at least 20 years in the Danish waters, when the greater part of these waters was covered with ice from mid-January to the end of March.

The locality best investigated is the Nyborg-fjord on the large island of Fyen. The sandy beach there was first inspected on the 4th of February. Owing to the continuously low level of the water it had been above water level for 4 days and the sand was frozen to a depth of 15 cm. In this frozen sand *Nereis diversicolor* was found, all the specimen being quite stiff, though some of them showed signs of life for a couple of days when brought into an aquarium where the water was at a temperature of 2 3° C. They subsequently died, however. In the next layer *Mya arenaria* was found, about 20 per cent. being dead and even decaying; some appeared to be dead but recovered when brought into an aquarium, while others were unharmed. About half a metre below the surface three specimens of *Arenicola marina* were found fully alive.

On the 21st of February the temperatures in the beach (lying dry) were ascertained.

At the surface of the sand	0.1° C.
- 10 cm.	0.6 -
- 20 -	0.8 -
- 40 -	0.8 -
- 60 -	1.0 -
- 80 -	1.2 -

The following percentages of animals found in the area dug out were dead.

Mytilus edulis	ca. 100	per cent.
Littorina littorea	- 100	—
Cardium edule	- 80	—
Nereis diversicolor	- 70	—
Arenicola marina	- 63	—
Mya arenaria	- 50	—
Macoma baltica	- 23	

On inspecting several localities it was generally found that the surface specimens had sufferes most, and the digging form least.

In some places, however, e. g. on Samsø, very few dead animals were found, although the waters there had been heavily charged with ice for about 6 weeks. Inspection of the beaches there on April 14th shewed that though some few specimens of *Mytilus edulis* and *Cardium edule* were dead, the great majority of *Mytilus* and *Littorina littorea* were alive. It was

thought that the large masses of algae (*Fucus* sp.) that covered the beach had protected the animals.

At Middelfart also, where the ice period was relatively short, few dead animals were found — mainly *Mytilus edulis*.

The author is of opinion that the continuous cold is the direct cause of the death of the "surface" forms; for the animals living in the sand he thinks that suffocation is the reason. A. D.

A. C. Johansen. Mortality among Porpoises, Fish and the larger Crustaceans in the waters around Denmark in Severe Winters. Rep. Dan. Biol. Station no. XXXV, Copenhagen 1929.

In this paper the Director of the Danish Biological Station, Dr. A. C. Johansen, has accumulated all observations available as to dead fish and other animals in the Danish waters, with especial regard to the severe winter 1928/29. In the south-eastern part of the North Sea dead soles were caught at 15 to 25 fathoms in the last half of March and in April[1]).

Along the shores of Jutland no dead fish were found, but dead specimens of *Cancer pagurus* and *Portunus holsatus* often occurred in great numbers.

In the Baltic dead porpoises were taken in hundreds by the motor trawlers in the deep water near Bornholm, in which place the waters had been open nearly the whole winter. As porpoises are not normally abundant in this locality, it is thought that these specimens had congregated there when trying to escape the ice in the Belts.

From the Danish part of the Skagerrack no dead fish were reported, nor from the deeper parts of the Kattegat. From the shallow parts, however, dead cod and plaice were reported, as well as young brill.

In the Belt sea dead fish — especially cod, haddock, plaice and flounder — were caught, often in great numbers, in the nets in some places only, mainly in the waters to the S.W. of Ærø. On the beaches eels also were found, of which 250 to 300 kg. were secured in one place.

In the fjords and other narrow waters dead eels and frequently *Gobius niger*, *Zoarces viviparus*, *Pleuronectes flesus*, *Gadus callarias*, *Clupea sprattus* and others were found in great quantities.

The author is of opinion that the cause of death generally is the cold water. In some cases (the porpoises) it is the ice itself, but in others it is want of oxygen, as, for example, in the waters S.W. of Ærø. In those waters the oxygen is often entirely absent, as is the case in many narrow waters.

The area where dead fish were found is generally very limited, and the author is of opinion that the stock of fish has not been seriously injured. Perhaps the most affected is the eel. A. D.

H. O. Bull. Studies on Conditioned Responses in Fishes. Part II. Journ. Marine Biol. Assoc. N. S., vol. XVI, no. 2, Plymouth 1930, p. 615—637.

In this second paper Mr. Bull continues his experiments on training fishes to react in a special way to special sense-impressions.

[1]) J. du Conseil Vol. IV, Nr. 3 J. R. Lumby and G. T. Atkinson: On the unusual Mortality amongst Fish during March and April 1929 in the North Sea.

Thus, a wrasse (*Crenilabrus melops*), that had previously been trained to enter a bottle for food when a tuning-fork was vibrating, now had to learn to enter another bottle when an electric buzzer was sounding. When it seemed that the fish had learnt the difference, critical experiments proved, however, that it had reacted not to the difference of the sounds themselves but to their different positions in the aquarium.

A plaice (*Pleuronectus platessa*), a coal fish (*Gadus virens*) and a cod (*Gadus callarias*) learnt to go to a food box in the aquarium when a light was turned on above another part of it.

Interesting experiments were done on the gustatory sensations of blennies. Two specimens of *Blennius gattorugine* could be trained to come out of their jar to a feeding place in the aquarium when a 0.5 per cent. or a 0.4 per cent. extract of Nereis was brought into the jar, and one of them continued to react even when the solution was diluted to 0.01 per cent. A *Blennius pholis* could not be taught to react to artificial musk, but learnt to react positively to a 0.5 per cent. extract of Mytilus and then showed the same reaction when this extract was diluted to 0.0075 per cent. With lower concentrations no reaction could be obtained. Another *Bl. pholis* learnt to react to the same concentration of an extract of Patella. No Blenny could be trained to react to artificial musk.

According to Mr. Bull one of the principal objects of his investigations was to compare his results with those of other investigators on the dog. To me it seems that it would be more important to compare them with the results obtained by other investigators who worked with fishes. Thus, Stetter trained several fresh-water fishes to react differently to different tones or sounds, Strieck trained *Phoxinus laevis* to react to sugar, vinegar, quinine or NaCl and to non-biological odourous substances like skatol, cumarine and musk, etc. It certainly would improve the importance of Mr. Bull's results if in a future paper he would take more account of the work which other investigators have done in the same line with other fishes.

J. A. Bierens de Haan.

J. H. Orton. Experiments in the Sea on the Growth-inhibitive and Preservative Value of Poisonous Paints and other substances. Journal of the Marine Biol. Assoc. N. S. Vol. XVI, no. 2. Plymouth 1930.

This voluminous paper is chiefly concerned with a comparison of certain proprietary anti-fouling paints referred to by number, and subsequently analysed in the Government Laboratory. They were painted on wood and on scallop shells (*Pecten maximus*), and exposed in various situations near Plymouth. The paints differed very considerably in their action, some having hardly any effect in inhibiting the growth of marine animals and plants. Analysis showed the best paints to be those with a high proportion of copper, with or without arsenic. Thus, in an appended report of the Government Chemist, a certain green paint is recorded as containing 14.8 per cent. of cupric oxide and 5.0 per cent. of arsenious oxide, but no cuprous oxide. The copper appeared to be present partly as insoluble basic sulphate and partly as Scheele's green (acetoarsenite of copper). Another active paint was reddish in colour and contained 11.8 per cent. of cuprous

oxide but only traces of arsenic and no cupric oxide. It was shown by scraping off the paint from boards which had been exposed in the sea and become overgrown in patches, that in the case of the green paint the cupric oxide had been reduced to 2—4 per cent. where growth had occurred, but remained high (7.5—15.2 per cent) in the sterile patches. Of the arsenious oxide not more than 0.7 per cent. remained in any case. It is evident therefore that the paints inhibit growth only so long as they contain a sufficient depot of poisonous constituents, the most important of which seems to be a copper compound. Such a depot does not act by its mere presence, but only in virtue of the fact that it is continally giving off ions to the surrounding water, and thereby depleting itself. A good toxic substance should therefore have a very small yet sufficient solubility in sea water, in order to exercise a prolonged effect.

These considerations apply, in the reviewer's experience, also to the protection of timber against *Teredo*, which being a borer, is kept out more easily from the interior than growth is kept off an outside surface. It is for this reason that protection against *Limnoria* working on the surface of wood, is more difficult. The phenols which by many are considered desirable constituents of creosote, are comparatively soon dissolved out by the sea water, and the prolonged action of the creosote seems to be due to other less soluble constituents.

Dr. Orton lays stress on the erosion of the whole paint (as distinct from the solution of some of its constituents). To counteract erosion the paint should be put on a dry and slightly roughened surface, but even then erosion is the real limiting factor and he concludes that if ships are to be kept free from growth for years, some method other than painting will have to be employed. In a final section the author reports observations on the rapid growth on ships' bottoms, examined at Plymouth after voyages from a variety of foreign ports; he thus captured several small South American crabs. G. B.

G. F. Mc.Ewen. Methods of Estimating the Significance of Differences in or Probabilities of Fluctuations due to Random Sampling. Bull. Scripps Inst. of Oceanography. La Jolla. Cal. U. S. A. Tech. Ser. Vol. II, No. 1. Berkeley, Cal. 1929.

This paper treats of what has been termed by Karl Pearson the "fundamental problem of practical statistics". This is the problem of determining from experimental samples of measurable quantities the probability of their accordance in varying degree with future samples and with the sampled "universe". The paper is practical in the truest sense, since no theory is included which is not applied to the solution of real problems in statistics.

The introduction sets forth the objects of the paper, and gives a very useful and comprehensive summary of its contents (p. 4). On pp. 5—6 is explained a method for estimating the significance of the difference between two proportions. This method is directly applicable to many problems in fishery statistics, for instance that of comparing the proportionate quantities of males and females in two populations of fish. Table 6 (pp. 23—107) is to be used in conjunction with the method. On pp. 6—17 methods

are developed for estimating the significance of the difference between two averages by means of "group proportions". These methods are new and are illustrated by practical applications to problems concerning the distribution of marine plankton. They suffer from the defect of not being entirely rigid, depending on the choice of "separating values", which divide higher frequencies from lower. Since, however, assumptions are made limiting the choice of such separating values to a narrow field, here should not be any appreciable error in the results due to the personal equation. Table 6 is again used with these methods, and a note on the use of Table 6 follows on pp. 18—19. On pp. 20—22 is discussed PEARSON's exact formula, derived from BAYER's Theorem, for calculating future probabilities from past experience and certain approximations are given for facilitating the application of the formula. The formula is used for the calculation of Table 6, and in connection with theory discussed subsequently.

On pp. 108—117 a method is discussed which was developed by "Student" for estimating the significance of differences between pairs of observations made with a view to investigating the effect of one given factor which is in action in the case of one member of each pair, and not in the case of the other member. Care must be taken that all other factors have the same effect on both members of any one pair. The method, in connection with which Table 13, pp. 118—122, is used, gives far more precise results than those in which the members of the pairs are grouped before comparison, or in which the average of two sets of observations are compared. It has the advantages, too, of being rigid and quite simple in application. There must be, of course, the same number of observations in each set, and this, combined with the necessity that the two observations of each pair must be made simultaneously (unless time be the factor under investigation) renders the method difficult of application in very many cases in fishery research. For instance, to use it in investigating the significance of differences in planktonic content of water in two different places would necessitate the use of two vessels making simultaneous observations. "Student's" procedure shows, however, that it is important to bear in mind the superior degree of precision which the comparison of pairs of observations has over that of groups of observations or their averages.

On pp. 113—117 is discussed the extension of "Student's" method to cases in which the number of observations in the two series is different. These methods, which are simple in application, should be useful, but the fundamental idea of comparison between paired observations is, of course, not adhered to, and precision is lost thereby.

On pp. 123—127 the relation of the Binomial Series with various frequency laws is discussed; pp. 128 to 131 contain a table of values of the Normal Probability Integral and certain related functions; on pp. 132—134 numerical illustrations of computations relative to the Binomial Expansion are given, and the paper concludes with a list of literature cited.

The paper is a timely collection of methods all of which are applicable to problems in fishery research. They are not quite so simple to use as those depending on the application of the Normal Theory of Error, but in the very numerous cases in which samples are small and there is no

reason for assuming that the frequency distribution of observations follows the Normal Law, their use is indicated. It should be said, however, that their applicability depends, as does that of the Normal Theory, on the assumption that the said frequency distribution is continuous, and not compound, and that their use in cases where this assumption is not justified would give results having no comprehensible meaning. The majority of cases of frequency distributions in fishery research appear to be of the latter kind.

H. J. B.-W.

Correspondence.

20th September 1930.

To The Editor, Journal du Conseil.

Dear Sir,

In an article published in this journal (Vol. III, No. 2, 1928) I described a convenient type of bottle designed and used by me in our drift bottle experiments. This bottle, which appeared as "fig. 2" in the article concerned, has a special feature facilitating the attachment of sub-surface drags, and has been made for us in large numbers by a commercial firm of bottle makers. Bottles with such a pierced bulge at the bottom to take a wire, were, I thought at the time, novel.

On consulting anew published accounts of certain Italian drift bottle experiments, I find that in a paper by L. Marini (R. Com. Talass. Ital., Boll. Bim., Num. 29—30, Venezia, 1914) a bottle having this feature is figured, and I desire, therefore, to draw attention to the fact that our Italian colleagues first had this idea carried into practical effect.

Yours faithfully,

J. N. Carruthers.
Fisheries Laboratory, Lowestoft.

Current Bibliography.

Prepared by the Editor with the assistance of Miss THURSBY-PELHAM.

NOTE. The scope of the Bibliography is limited in the main to the area covered by the Council's activities, but there are included papers of general interest relating to other areas in the North Temperate and Arctic regions and exceptionally elsewhere. Limnological references are not as a rule given, but papers relating to brackish waters and to salmon and freshwater fish studied by the Council are included.

The classification of entries follows in a general way that adopted in Dr. ALLEN's Selected Bibliography published in Vol. I, Nos. 1 and 2 of the Journal, and since reprinted (Price, 1 Kr.).

Subscribers and those on the distribution list will receive regularly upon application to the Administrative Secretary copies of the Bibliography printed on one side of the page only, for use in making up card indices.

The Editor will be glad to be advised of emendations and additions to the Bibliography.

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